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THE SCIENTIFIC MONTHLY

NOVEMBER, 1921

THE SECOND INTERNATIONAL CONGRESS OF EUGENICS[1]

THE FIELD OF EUGENIC REFORM

By Major LEONARD DARWIN

THE section of which this is the opening meeting deals with eugenics in relation to the state, to society and to education; it may be described as the section for applied genetics. I have been tempted to describe it as the section for practical eugenics; but that description would hardly be appropriate. The details of experimentation and research fall outside our sphere; but to make experiments is the most practical thing one can do. Your practical manufacturer knows full well that if he trusted to running forever on the old lines he would soon come to grief. We are, therefore, here dealing with the practical application of knowledge acquired by practical research.

Differences of opinion no doubt exist amongst those who have conducted the researches on which we have to build our practical superstructure; differences both as to methods and as to results. Even more marked differences are, however, sure to be felt in this section, where we have to apply to human conduct the knowledge acquired by others. Ought this to alarm us? I think not. I remember long ago seeing a picture in our English *Punch* in which a tailor is depicted when making excuses for some misfit as saying, "You must remember, sir, that tailoring has not yet been reduced to the level of one of the exact sciences." My views about eugenics are somewhat similar, though that is not the way I should express them. But we must remember that, as evolutionary science teaches us, uniformity always means stagnation. If we all felt alike, no one of us could ever pick up from a neighbor any wiser thoughts than his own; and we should therefore neither regret a certain amount of divergence of opinion nor attempt to hide it. If the beasts of the field had never fought together in the struggle for existence, mankind would never have been developed out of our ape-

[1] Held at the American Museum of Natural History, New York City, from September 22 to 28, 1921.

like ancestors. But do not mistake me. I am not advocating war, which is the most damnable thing on earth both as to its immediate and its racial consequences. We must obtain the benefits which did result from savage warfare in some other way; but competition we must have in everything, our opinions included. If any other eugenist should disagree entirely with my assertions, I shall feel in no way hurt!

But what is the foundation on which we, in this section, have to build? As I have already stated in this room, I hold that our aim as eugenists should be to increase the rate of multiplication of stocks above the average in hereditary qualities and to decrease it amongst the less fit. Others may wish to make our efforts cover a wider field, holding, for example, that the immediate benefits likely to arise from the teaching of sex hygiene should be included. With such as these I shall not quarrel for I am in full sympathy with their aims. But I do think that as a matter of convenience it would be as well to restrict the meaning of "eugenics" so as to make it cover no more than was intended by Sir Francis Galton who coined the word, that is, that it should apply only to measures affecting the inborn qualities of future generations.

Now as to the differences of opinion amongst us, I am glad to think that we are not divided into definitely antagonistic camps; for all are, as it were, linked together by the existence of every intermediate shade of opinion. No doubt at one end of the scale there are eugenists who regard racial progress as an assured law of nature, a progress merely to be hastened by the elimination of certain extremely undesirable types, such as the insane, the feeble-in-mind, and those endowed with grossly defective inborn constitutions. At the other end of the scale are those who regard the signs of the times as pointing without doubt to a slow and progressive deterioration in the innate qualities of all civilized peoples; that is, to national degradation, which it will only be possible to arrest by national efforts covering a wide field of endeavor. In short, though all eugenists aim at improving the inborn qualities of posterity, yet some would attack on a wider front than others. In this connection it may be convenient also to divide inborn qualities into two groups; groups which also can not be separated from each other by any very definite line of demarcation. At one end of the series we have qualities dependent on a single something which the child received before its birth from its parents, whilst qualities at the other end of the series depend on a large number of such somethings; just as we may divide tables into those which have one leg and those which have many supports. In technical language, the distinction here suggested for consideration is that between qualities dependent on a single Mendelian factor—or let us say on one or but few such factors—and qualities dependent on large numbers of factors. The qualities belonging to these two groups demand somewhat different treatment,

and some eugenists attach more importance to the one group and some to the other.

Let us first consider the single factor qualities—the one legged tables—in cases where such qualities are harmful; and let us take as a single example a deformity called brachydactyly, the symptoms of which are the fingers being excessively short. Now a child before its birth either has or has not been endowed with the factor resulting in this ailment. If it has not, it will not show these symptoms, and there is an end of the matter. If it has been so endowed, it is certain to have its hands crippled in this way, and it is, moreover, certain to pass on this deformity to many of its offspring. How the factor first arose in the ancestry of the brachydactylous child is unknown; but its apparently spontaneous appearance is at all events such a rare event that for practical purposes it may be neglected. This is the very simplest eugenic problem with which we have to deal; for if we could prevent parenthood in the case of all brachydactylous persons, we might thus stamp out this ailment forever. The matter is not often quite as simple as this; for, in regard to many defects, the child must receive the harmful endowment from *both* parents in order to be harmed thereby. If the endowment be received from one parent only, its recipient is apparently normal; but all the same he is the carrier of this hidden evil, very likely to be passed on to future generations, and to show its harmful effects when it chances to be combined in one individual with a similar endowment from another line of descent. Here also all that can be done is to prohibit parenthood in the case of all those who, by exhibiting the symptoms in question, show that they have the double dose of defective heredity; though here the beneficial effects will be more slowly obtained. In both cases all that has to be decided is whether the defect in the present and in all future generations constitutes an injury sufficiently grave to justify, *in this one generation only*, the actual prevention of parenthood or the self-sacrifice needed for its voluntary abandonment. The world could be freed from all such ailments more less quickly, and it is only a question in each case whether it is worth the cost of thus freeing it. But please note—and this is the point to which I especially wish to call your attention—if we were to rid the world of any one of these single-factor hereditary effects we should probably thus benefit mankind in no other respect.

Here I cannot refrain from saying a few words about the feeble-in-mind; though to do so is in a measure to depart from the thread of my argument. Whatever may be the final verdict of science as to the nature of the factors on which this grave evil depends, all experts now agree that it should be treated in the way in which single factor qualities should be dealt with; that is to say, each case should be studied separately and dealt with on its individual merits. Here in the United

States you have at least three hundred thousand or four hundred thousand of these unfortunates, and the numbers would probably be far greater if high grade cases were to be included. A very large proportion of the mental defectives who become parents will pass on this ailment to many of their children; whilst many of their offspring, though apparently normal themselves, will be endowed with the power of transmitting this to their descendants; and, if the interests of posterity are not to be grossly neglected, no feeble-minded person should be allowed to become a parent. Moreover, those who have studied the problem, all of them, I believe, agree that the right method to adopt is, as a rule, segregation; by which is meant confinement in comfort, the sexes being kept apart. We all hate interfering with liberty; but let it always be remembered that liberty necessitates equality, and that as equality is impossible with the feeble-in-mind, they can under no circumstances ever have true liberty. Segregation is unquestionably the kindest course to adopt in most cases, especially when all the natural protectors of the afflicted have disappeared. The creation of the necessary accommodations would present difficulties, but it would be a national economy in the long run.

There is, however, one difficulty to be faced which some eugenists have passed over too lightly. The feeble-in-mind often attract to themselves far more affection than would be expected by the inexperienced, and in nearly all cases the mother has strong instinctive sentiments in regard to her children. The removal of the mentally defective infant from its home is in consequence often keenly resented; a resentment which may no doubt frequently be overcome by argument, except when it is backed up by less reputable desires dependent on the possible economic advantages to the family. Here is a difficulty which must by no means be neglected; though in my country at all events, what is now greatly needed is to make the segregation of the mentally defective more easy, not more difficult, than it is at present. Now these conflicting considerations have forced me to consider what part sterilization could be made to play in the eugenic program. It is not for me to discuss what has been done in this respect in the United States; for there are many present who can deal with this topic better than I can. I am aware that the American Breeders Association has investigated this subject with care, and I wish to urge as strongly as I possibly can that a continuation of these scientific researches is the most practical thing that can now be done. We want to know what is the best method of sterilization, and what are all the objections to it. Is the X-ray method to be relied on? What effect would it have on the offspring if insufficiently applied to produce sterility? Is there any danger of cancer as a result? I strongly press this inquiry with regard to X-rays because I think that the adoption of surgical methods does

increase the prejudice against sterilization, especially in regard to the operation needed for women. The prejudice itself is very likely to be instinctive; for natural selection is almost certain to have eliminated all mental traits which are opposed to procreation. If this be so, this is a prejudice certain to be met with, and only to be overcome by reason.

If a sufficiently safe method of sterilization is available for both sexes as some experts now hold to be actually the case, would it not be a useful auxiliary to segregation? Mentally defective persons ought to be allowed to live at home, or boarded out where they can be useful provided that ample precautions are taken to make it certain that they can thus be maintained in equal contentment to when living in an institution, that all other conditions are suitable, and that procreation will be very improbable. Might not voluntary sterilization be regarded as a strong plea in favor of permission being given by the authorities for the mentally defective person not to be taken to an institution? Many parents would, I believe, gladly welcome this alternative, if carefully explained, in order to retain their child under their own care; though here again it should be ascertained that the home conditions are all suitable. No doubt sterilization may in some cases facilitate immorality; but if the authorities were given power to enforce segregation in the case of all sterilized persons found to be living an immoral life, the harmful consequences might be largely diminished. I am myself inclined to favor the introduction of sterilization as a voluntary and experimental measure; for if it proved to be successful, its use would certainly be extended, its racial advantages being obvious.

To revert to my main theme, we have seen that as regards such bad qualities as are dependent on one or but few mendelian factors, the right course to adopt is to consider and to deal with each case separately; and this is no doubt the way in which many eugenists wish to treat all such human qualities as need be considered. Probably we shall all agree that the grossly unfit whether they be habitual criminals, utterly incorrigible wastrels, or those endowed with excessively bad natural constitutions, ought not to be allowed to become parents, each individual being separately weighed in the balance. But most of the bad qualities leading to gross unfitness are dependent on many factors, and what I now wish to suggest for your consideration is that the recognition of this fact ought to make us modify in certain respects the policy which we recommend for adoption. To make the point clear it will be better to turn to the consideration of good qualities and to study the methods of increasing the rate of multiplication of those well endowed by nature. No single good qualities known to me can be certainly attributed to the presence of a single factor; and if we consider the make-up of a man of genius, including reasoning power,

concentration of mind, energy, perseverance, faculty of observation, et cetera, et cetera, we may feel sure that many factors are involved. Almost every student of eugenics has at some time or other during his career attempted to sketch out schemes for the individual selection of a number of highly endowed persons, for inducing them to marry superior mates, and for the encouragement of the production of large families by these selected couples. Ought we not, therefore, to inquire to what extent reliance is to be placed on such methods when the qualities involved are dependent on many factors? The matter is complicated; but as it is one to which I am very anxious that the attention of eugenists should be directed, I beg for your patience whilst I try to illustrate the point in question.

If a few millionaires were to be selected, and all their wealth were to be distributed broadcast amongst the people, we may be certain that the result would be a feeling of keen disappointment amongst the originators of the plot, for each recipient would receive such a minute share of the booty. Again, if it were possible to create a few millionaires, wealth and all, and if generation after generation, their descendents were to dissipate this newly created wealth until it was widely scattered throughout the whole land, in this case also the ultimate benefits to the mass of the people would be very small. Now the eugenist who wishes to see a number of eminent persons picked out and induced to produce large families is no doubt aiming at what would be equivalent to the creation of a number of distinguished persons in the coming generations; and I do not doubt that at all events as regards the next generation only, a marked success in this respect could thus be reaped. But we have seen that the good qualities of the selected parents would be due to many factors; and these factors, like the money of the spendthrift descendants of our millionaire would tend to become more and more widely scattered amongst the people in accordance with an inevitable law of nature; the final result being, we may be equally certain, very disappointing to the eugenist, as far as ultimate racial results are concerned. If we want more millionaires—I am not saying whether we do or do not—one way to secure their presence in greater numbers in the future would be to raise the level of the wealth of the whole people; for the more we were to enrich the soil of any country, as it were, by increasing its total wealth, the greater would be the number of its inhabitants who would in the ordinary course of trade grow so rich as to become millionaires. In nearly the same way, if we want more persons eminent in morals, intellect, or physical strength to spring into existence in all the generations to come, the most certain method of achieving this result would be to raise the level of the whole people in regard to their inborn qualities. For if this could be done, the factors needed for the production of a

man of genius would exist in greater numbers; their union by chance in any one individual, or the actual appearance of a genius, would occur very often; whilst all the while the mass of the people would be receiving the benefits due to their improved natural endowments. Surely this then is a policy not to be neglected. [1]

The effects of the wide distribution of a millionaire's wealth, even though disappointing to those concerned, yet if accepted as an illustration of the racial consequences of increasing the progeny of a number of selected persons, certainly give a greatly exaggerated idea of the benefits thus to be obtained; and we must seek for some more accurate method of attempting to estimate the probable results. Sir Francis Galton stated that one man in 4,000 might be fairly described as being "eminent" in intellect; and we may perhaps in like manner describe the tallest of a group of 4,000 men as being eminent in stature. Now Frederick the Great is said to have picked out the biggest men he could lay hands on, and then to have mated them by no gentle means to very tall women,[2] with the object of securing a number of huge recruits in the coming generation. To what extent the royal aspirations were fulfilled in this respect I do not know. But let us follow Frederick's example in imagination and consider what would be the effect of such a scheme on the average height of the people in future generations. In a town of 8,000 inhabitants there would probably be one man and one woman eminent in stature and let us imagine that we bring these two together, with the result that two more children

[1] The analogy of the inheritance of money is, of course, faulty in many respects. With natural inheritance the chances of a person receiving a good endowment from his parents are the same whether he has few brothers and sisters or many. Again, many have no money to leave to their descendants, and often money is only received from one parent. With natural inheritance every one is certain to receive an endowment, good or bad, from each parent, and one endowment is as important as the other. Lastly, whilst we can aim at a more even distribution of wealth, it would be impossible, even if we would, to prevent the fortuitous coming together of the necessary factors so as to produce a man of genius.

[2] Frederick would have produced nearly the same ultimate results on the race if he had allowed his male and female giants to marry whom they liked provided their progeny increased. It has not been sufficiently recognized that, putting aside the effects of assortive mating, the only racial advantages of *mating* the selected individuals are (a) the immediate production of giants, for example, and (b) that greater results can perhaps thus be obtained for the same money, as one stimulus then affects two selected individuals. It should also be noted that if in consequence of their selection the selected persons were moved out of a more fertile into a less fertile stratum of society, and if their descendants remained in that less fertile stratum, then the ultimate results would be dysgenic, whatever might be the more immediate consequences. In these circumstances thus to create an improved type in perpetuity would necessitate the establishment of a rigid caste system.

are brought into the world than would be the case if we had not interfered. Looking to the male part of the population only—for simplicity and not out of disrespect to the female half—we should find that our tall man was rather under nine inches in height above the average; and, as a rough approximation to the truth, we may imagine that after many generations these nine inches would become evenly distributed amongst the whole male population of the town; or, in other words, that we should thus have raised the average stature of that town by a little more than one five-hundredth part of an inch.[3] If this be a true conclusion, as I believe it to be, you may judge that if you were to pick out the 12,500 tallest men and 12,500 tallest women in each generation in the United States, if you were to mate them together and if somehow or other you were to induce each couple to have two *additional* children, you would thus in about 1,500 years raise the average height of your citizens by one inch! In passing I can not help expressing my pity for any official in charge of a department of state dealing with any such duties! But what I really wish you here to note is that mental qualities though not as easily measured as physical characteristics, are distributed in accordance with the same laws and are no more easily improved by dealing with selected groups. Does not this way of regarding the matter throw serious doubts on the ultimate advantages of eugenic reform of this kind; that is, of picking out a comparatively small number of selected persons on account of qualities dependent on many factors. Our main endeavor ought to be to raise the level of the whole people in regard to their inborn qualities, for which purpose large numbers must be affected; and I am inclined to believe that the success of our efforts to promote racial progress will depend largely on this fact being fully recognized by eugenic reformers.

Since we are getting on well enough as we are, why not let things alone? Before adopting the hopeful attitude indicated by this inquiry we ought carefully to consider whether at the present time civilized nations are advancing or deteriorating in regard to their inborn qualities; a most difficult question to answer decisively. Here we enter the region where keen feelings are likely to be aroused; and, to avoid the distorting effect of prejudice, let us look to the future rather than to the present. Now these young men of to-day who are endowed with good natural abilities and constitutions will be nearly all certain in time to earn for themselves a fairly good livelihood, whilst the reverse will be the case with those ill-endowed by nature. Then again, those

[3] The increase in stature would in truth be materially less than .002 of an inch; for regression due to dominance and other circumstances has to be taken into account. See "Correlation between Relatives," R. A. Fisher *Trans. Royal Soc. Edin.* Vol. III, Part 2 (No. 15).

who are members of small families will receive greater advantages in education and in many other respects than will the members of big families and they will in consequence more easily win their way to the front. These two selective processes will be more effective as civilization advances; and as a result we may expect to find in the future in the ranks of the well to do a most harmful combination of qualities more and more often appearing; that is to say, superior inborn qualities more and more often combined with all those natural tendencies which tend to favor the production of small families; these latter including natural infertility and an innate desire to consider the welfare of children as yet unborn. The result to be anticipated is that, in comparison with the ill-endowed, the naturally well-endowed will as time goes on take a smaller and smaller part in the production of the coming generations, with a tendency to progressive racial deterioration as an inevitable consequence.[4] And if we ask whether existent facts confirm or refute this dismal forecast, what do we find? Statistical inquiries at all events prove conclusively that, where good incomes are being won, there the families are on the average very small. Moreover, history teaches us that in the remote past ancient civilizations, after rising to a climax, often began to sink and sink until they disappeared off the face of the earth. These problems are too complex now to be discussed at length; and I can only assert that I can find no facts which refute the theoretical conclusion that the inborn qualities of civilized communities are deteriorating, a process which must inevitably lead in time to an all round downward movement. I am, of course, regarding this question broadly and generally, but I can not refrain from adding that the United States has a mighty future before it, on which the civilization of the whole world may in a large measure depend. It is, therefore, doubly incumbent on its citizens to consider whether their best or their worst stocks are now multiplying most rapidly. If it is the worst stocks, and if no steps are taken to remedy the evil, then this country may in consequence miss an opportunity of filling a most glorious page in future history.

[4] The theoretical side of all these questions is here quite inadequately discussed. Many authorities have pointed out the effect of wealth in reducing fertility, a subject not here dealt with, though I have been convinced it is a most important factor. As to the possible influence of physiological infertility, see "Human Fertility" by J. A. Cobb, *Eugenics Review*, January 1913. As to the effect of mental traits on fertility and racial progress, see "Some Hopes of a Eugenist" by R. A. Fisher, *Eugenics Review*, January 1914. These topics have been discussed by me at greater length in "The Need for Widespread Eugenic Reform," *Eugenics Review*, October 1918; "Eugenics in Relation to Economics and Statistics," *Journal of Royal Statistical Society*, January 1919; "Some Birth Rate Problems," *Eugenics Review*, October 1920 and January 1921. See also "The Habitual Criminal," *Eugenics Review*, October 1914.

If in all civilized countries the forces the existence of which I have but too briefly indicated, are producing deteriorating influences by acting on the masses of the people, then the only way to counteract this tendency is to set in operation other forces which will affect large numbers in the opposite direction. But how is this to be accomplished? As to good qualities, what I hold to be the main remedy can be expressed in so few words that its great importance is likely to be overlooked. What is necessary is to make it widely and deeply felt that it is both immoral and unpatriotic for couples sound in mind and body to unduly limit the size of their families. No doubt difficulties will be experienced in deciding to what extent the duty of parenthood is imposed in individual cases; difficulties which I have no time to discuss. The main difficulty will, however, be to get this duty strongly felt by the mass of the people; for success in this endeavor would, I am convinced, have a much greater effect on the size of families than common sense alone would indicate. Failure is, however, certain if the problem is not attacked with religious zeal. There ought to be a great moral campaign against the selfish regard for personal comfort and social advancement, for these aims must in a measure be sacrificed on the altar of family life if racial progress is to be insured. We must all learn that if envy and jealousy could be banished, the happiness of our children would depend greatly on their inborn qualities and but little on their place in society. We should recognize that we shall best serve our country by bringing healthy and intelligent children into the world, provided that we can give them a sound education and a fair chance of winning a good livelihood; and all of us should be ready to make some sacrifice of social position in order to obey our country's call in this respect. The nation that wins in this moral campaign will have gone half way towards gaining an all round racial victory.

There are no doubt many economic methods of increasing the rate of multiplication of the people; methods which would be beneficial if applied to good stocks and harmful in the case of inferior types. The main reason why persons of high character limit the size of their families is in order to insure that all the children they do bring into the world shall have a good start in life. Obviously the simplest way to remove this check on fertility is for the state to step in and ease the financial strain on parents due to the upbringing of their children. This method must, however, never be applied indiscriminately or without consideration, for the qualities of the types affected must ever be held in view; and this is especially to be noted in connection with all schemes for motherhood endowment. Then again an increase of taxation is equivalent to an increase in the poverty or a decrease in the wealth of the persons taxed; and such a change in their prospects will tend to make all couples still further limit the size of their families;

unless indeed they are naturally incapable of taking thought for the morrow.[5] It follows that to increase the taxation on the more fit in order to ease the strain of family life amongst the less fit would do a double dose of harm; that is by decreasing the output of children where it should be increased and by increasing it where it should be diminished. There are no doubt evils which can not altogether be avoided; for we are bound to pay attention to the needs of all who suffer, whatever may be their natural qualities. If only looking to the types whose multiplication we want to promote, what we can safely do is to increase the taxation on the unmarried and the childless and, out of the proceeds, to give advantages to the parent of growing families *in the same social stratum*. In regard to all proposals such as that recently made in Australia, for directly or indirectly taking from all workmen a portion of their earnings and for distributing the money thus obtained amongst parents in proportion to the number of their young children, here again the racial effects will be good if, and only if, the benefits received by each couple are porportionate to the contributions made by members of the same group to which they belong, a condition almost certain to be neglected. The economic principles, which I have all too hastily alluded to, involve many puzzling questions in regard to their application; but to neglect them altogether is to court a great racial danger.

Turning to the consideration of influences which would tend to diminish the rate of multiplication of inferior types, we see that the grossly unfit can be separated from the normal population with but little doubt, and that they are often a serious nuisance to society. As regards most of these types it is probable that seven mendelian factors are involved; but even if that be so it is not improbable that some one of the resulting bad qualities may be due to a single factor. For all these reasons it seems right that the grossly unfit should be selected individually from the rest of the population, and that in their case parenthood should be prevented by segregation, with voluntary sterilization as an experimental auxiliary. But here also some attention should be paid to the principle which I am advocating, namely, that with qualities dependent on many factors it is as a rule best to aim at dealing with large numbers rather than with the extreme cases. Taking the criminal population as a single example, it is found that those who have been frequently in prison are practically certain to revert to crime when liberated. These habitual criminals form the bulk of the prison population; they have no good qualities to recommend them; they are too stupid to avoid detection, and the only courage

[5] It should be noted that I am speaking of an *increase* of taxation and not of high taxation. The ultimate racial effects of high taxation are difficult to foretell.

which they show is that needed to face disgrace and imprisonment. Merely to reduce the fertility of large numbers of this class would be more beneficial from the racial point of view than to absolutely prohibit parenthood in the case of a small number of persons convicted of grave crimes; persons who at all events are often intelligent and courageous. With the habitual criminal the length of detention should be increased and its severity diminished after each conviction; periods of liberty should be given until it is quite certain that no cure can be effected; and in the end the malefactor should be regarded as a person to be permanently detained because he is incapable of self management, all idea of punishment being abandoned. The benefits thus to be derived are indicated by the statistically proved facts that lengthy imprisonment does lessen the number of progeny of the criminal, and that his children are at least ten times more likely to be sent to prison than are the children of honest parents. Even those who do not believe in heredity may, therefore, be inclined to hold that permanent segregation is justifiable after many convictions. We should endeavor to deal in the same way with the wastrel, the drunkard, and the work shy; that is as members of large classes the size of which ought to be diminished rather than as individuals requiring separate consideration.

If it be true, as I hold, that there are hidden forces continually at work tending to relatively increase the rate of multiplication of large numbers of those who are below the average in the various qualities held to be desirable, then efforts to deal with the obviously unfit would not alone stem this tendency toward racial deterioration. To prevent our civilization from slowly sinking in the future, some far more widespread action is needed. But how are we, it may be well to ask, to pick out large numbers of the population whose hereditary influence on posterity will tend to drag down the average?[6] Now we shall all probably agree that the fewer young men there are in any country, who prove themselves to be incapable of winning sufficient wages to maintain a family in decency, the better it will be for the community as a whole. This is true even if we only look to the comfort and well being of the children destined to be born in these ill-found homes. Here we are of course tempted to urge that the state should step in and see to it that no disadvantages are felt by the little unfortunates likely to be brought up in bad surroundings for which they would be in no way responsible. Any such action would, however, increase the birth rate of the class affected. Now bad surroundings doubtless tend to increase the number of social failures; a cause of failure which, we may believe will become less and less operative with every advance in civilization. But a very large proportion of those incapable of support-

[6] It must be remembered that this must be true of half the population.

ing a family in decency in normally prosperous times are characterized by certain inborn defects; such as weak constitutions, inferior mental powers, unstable moral qualities, etc., all of which are in a measure to be passed on to posterity. State action of the kind just suggested must therefore be harmful in its racial effects; for we ought to check rather than to increase the size of families born in squalid surroundings. How can this be done? This is a problem to which I most earnestly hope that eugenists will turn their attention; for I confess I have found myself no very satisfactory solution. I can only suggest that state and charitable aid should never be given in such profusion as to prevent the appearance of each child from causing any additional financial strain on the household, for fertility is decreased by financial pressure; but I hardly know what to suggest in the case of those who in spite of this pressure persist in procreation in evil surroundings; and perhaps for the present we should concentrate our attention on the attempt to secure a general approval of the desire to lessen the output of children in such circumstances. But the problems involved must be solved sooner or later, and in attempting to solve them we must remember that every reform does harm as well as good, and that all we can do is to make reasonably certain that the good results will preponderate over the evil. In order to prevent the civilized nations of the world from slowly losing what has been won by long ages of suffering, no doubt sacrifices must be made and some suffering yet endured. But if we have courage to face this problem without flinching; if we fearlessly advocate what we hold to be right, in spite of the unpopularity of the safeguards and remedies we suggest; and if we can in the end secure wide approval of our aims; then I am myself certain that we shall be able to introduce reforms which will secure untold benefits for mankind, in all the long, long ages to come.

In conclusion may I once again indicate the contrast which, I suggest, ought always to be held in view in framing plans for eugenic reform; a contrast which I have painted with such a broad brush that many qualifications have of necessity been omitted and many points but ill-explained. I have endeavored to show that, for the purpose of our discussions, human qualities may be divided into two ill-defined groups, with intermediate types between them. At the one extreme there are the single factor qualities; in the case of persons possessing bad qualities near this end of the series, they should be individually selected and examined and then each treated accordingly. Here we should be dealing for the most part with pathological cases or with persons who are likely to become a nuisance to society; the aim of the eugenic reformer would usually be to rid the world of some definite defect. These are the cases which are least in dispute, and where racial benefits can be most rapidly obtained; and for these reasons it is perhaps

to these qualities that our attention should first of all be directed. At the other extreme are those characteristics which separate whole classes of a community from each other, and which obviously depend on a great many factors. Here we generally have to look to the class as a whole, and to apply such remedies as do not necessitate the selection of individuals, the aim being to raise the level of the whole people. It is on such qualities as these that the slow improvement or deterioration of our civilization will in the main ultimately depend; and if they be neglected in our schemes of eugenic reform, we shall before very long begin to lapse back again towards barbarism, thus following in the footsteps of many highly cultivated nations in the past. On the other hand, if our biologists face these problems more earnestly in the future than they have in the past, if our politicians pay more attention to the advice of scientific experts than has hitherto been customary, and if the general public will be guided by common sense in regard to heredity, then I hold that we shall have more right to look with confidence to the future than ever has been the case since the dawn of civilization.

THE CONSEQUENCES OF WAR AND THE BIRTH RATE IN FRANCE

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AS a result of the war, the France of 1914 has lost 1,400,000 of her inhabitants in the prime of life, most of them fit for producing children. And among the survivors of the fighters of the great war, a certain part of the 800,000 total invalids will never be able to produce strong healthy children, either because they are no longer capable of marrying, or because they are affected with tuberculosis or other constitutional maladies.

To these direct losses must be added the loss of births. Before the war, the number of living births balanced with a slight excess the number of deaths; the annual number was about 750,000. During the six years from 1914 to 1919 inclusive, the deficit reached 400,000 births, which ought to have survived normally and which were lost owing to the war.

On the other hand, deaths in the civil population have been more numerous than formerly, so that 400,000 more deaths are added to the 1,400,000 unborn and to the 1,400,000 soldiers killed in war, giving a total of more than 2,000,000, taking into consideration possible repetition and immigration. These results are calculated on the supposition that, in the invaded regions, the loss, estimated proportionally to the number of inhabitants, was the same as in the uninvaded territory; on the other hand, the numbers are applied to the territory of 1914, but Alsace and Lorraine can not nearly fill the loss of population of this region. The provisional results of the census of 1921 confirm these suppositions.

But that is not all. Privations have broken down the health of many children born during the war or a few years before, especially in the regions of the northeast, where, during the German occupation, they lived in a state of veritable physical misery. Indeed, infant mortality, even in the uninvaded districts, has been notably higher during the war than before, in spite of the low birth rate.

Finally, a certain recrudescence of alcoholism, tuberculosis, venereal disease and various nervous diseases influenced unfavorably the vitality of the nation and the race.

Many years will be necessary to repair the loss of population, direct

or indirect, attributable to the war or to the evils which have accompanied it.

To avoid the inauspicious consequences of these miseries, certain people believe it is necessary to encourage procreation by all possible means; they do not fear an excess of population for a long time. Others think it expedient that each man of proper age to have offspring should have the 3 or 4 children necessary to permit a moderate increase of population. And still others estimate that a continued increase of population would create an economic peril and contain the germ of future wars. Again some wish certain restrictions, especially in confinements, among the poorest of the population, to improve the quality of this population.

The considerations which are the most important are the following, which shall be examined from the point of view of eugenics and the point of view of economics.

I.

To-day, respect of human life in all its degrees makes us condemn infanticide and abortion. There remains then as a means of artificial selection only the prevention of births.

But the universal concern which determines parents to limit the number of their children is the burden, at least momentarily, which the latter represent.

The question of the birth rate, in its entirety, with an exception to be referred to later, comes back again to a question of economic morale. For physical passion finds play without producing the being which is its end, and this being is often to-day the reward of a sacrifice freely agreed upon.

Humanity ought not to perish by its own error. Such is the higher principle which ought to be reconciled with the practical impossibility of unlimited multiplication.

According to etymology and the definition given by Galton, eugenics is a general study of the improvements of which the race is susceptible, race being characterized by common physical or mental qualities manifesting themselves in certain groups of men and differentiating them from other groups. Two conceptions enter here, that of improvement, and that of the race. To what realities do they correspond?

We cannot define progress, the process of making perfect; but, when we look back, we feel the differences which separate the life of other times from that of the present; evolution appears to us to follow a certain direction. We can then legitimately aim to continue life in this direction.

In the second place, although in a biological sense pure human races are not numerous, one can prove that a number of groups of in-

dividuals are distinguished by their physical and mental characters, apparent and distinct as a whole, from another group. Without modifying these characters to the point of making the differences disappear, one can improve their manifestations, the manner in which they act in each human group; that is the aim which eugenics seeks. But we must not lose sight of the fact—for other sciences, the science of education for example, seek the same end—that eugenics is concerned, it seems, only with measures capable of effect upon descendants, that is to say, transmissible by heredity or capable of operating a selection advantageous for future generations.

The general principles of this new science have not yet been well established. It is not yet settled; it is still in a period of development. And this permits some liberty, some difference of opinion to those who try to attack the problem.

There are, however, acquired facts, indisputable connections; for the moment we may withdraw to this ground.

Whatever our opinion as to the relative importance of the factors heredity or environment—that is the principal point on which personal opinions are opposed—the influence of heredity can not be denied. Physical and mental resemblances of parents and children are obvious; the hereditary transmission, at least in the most closely related generations, of certain physical peculiarities, such as stature, conformation of the skull, hemophilia, polydactylism, etc., or of mental defects such as epilepsy, certain forms of mental deficiency or feeblemindedness, are to-day almost proved. Provided always that the tendencies involved are simple and that their existence can be removed, resemblances between children born of the same parents do not prevent great differences sometimes appearing in these children. The heredity of abilities or that of defects is not a matter of fate: education may modify nature.

As to the influence of environment, of the mode of development of the created being, whatever may be its importance for this being itself, the question which interests eugenics is to know whether this influence acts upon the descendants after being hidden for a number of generations. On this point, certain savants, Weismann in particular, have declared negatively. Others have shown, by experiments on lower organisms, that organic modifications brought about in these organisms are transmitted to their descendants.

As Dr. Apert has remarked in France, as far as man is concerned, it seems that only the modifications relating to the nervous system have yielded, up to the present, observations truly conclusive. Yet the interpretation of these facts has been contested; they have been attributed to hereditary predispositions, but it is always easy to draw into the re-

sults of an observation the effect of a hidden influence as mysterious as that of heredity.

Our knowledge is not sufficient to warrant our issuing a challenge on these obscure questions. And yet of such great importance to humanity is a sustained and growing development of scientific researches relative to the heredity of man, that this is the desire of all those who are interested in eugenics.

The transmission of character, from one generation to another, works through the germ-plasm, but this action can be guided by selection: natural selection by death, artificial selection by sexual union.

M. Edmond Perrier, president of the Société française d' Eugénique, recently stated that, in primitive nature, natural selection may not have had the exclusive effect which the Darwinians have attributed to it. Moreover, what precisely is natural selection? Does it mean simply that an individual incapable of adapting itself to the conditions imposed on it by environment disappears and only those individuals survive who are capable of adapting themselves? That does not add a great deal to our knowledge, as Mr. Balfour (speaking before the First International Eugenics Congress) remarked, since it amounts to saying that only those are capable of surviving who survive a veritable truism. And if one means that only those survive who are capable of surviving, M. Perrier answers (*Eugénique*, mai 1921, page 197) that those who are incapable of surviving in one region can escape death by flight, and it is thus perhaps that the living world has evolved.

In truth, death and survival are a form of selection from which may result for humanity, as for all living beings, good or evil according to the qualities of the individual involved and the surrounding circumstances. If we are unable to modify the innate qualities of the individual, we may often, by acting upon the surrounding circumstances, make useful the qualities which it has.

This is one of the essential duties of eugenics: to favor and encourage the work of health and the work of educating the promoters of social progress.

As to artificial selection, we may endeavor to increase births among those who possess the best qualities and to decrease births among those who show defects and faults. However, we ought to ask ourselves whether there does not exist now and then a certain opposition to these two movements: that which makes for the improvement of conditions of existence and that which makes for the best qualities in the descendants.

Opposition has been noted many times, especially among English eugenicists. Nature, they say, in a convenient anthropomorphic language, nature has arranged for the beings least endowed for life, to disappear before those who are better endowed. This observation

is just; admitting that in the shadowy beginning of life, flight was a means of preservation, this means is not worth much when it is impossible to flee from danger. This is the case when illnesses and bodily struggles cause the disappearance of the least worthy beings, the least capable of resistance. But when human fraternity, pity, science, and hygiene unite their efforts to defend the weak, many individuals who would have disappeared if left to themselves, live in spite of their disabilities and transmit these to their descendants. As is often remarked, the humanitarian tendencies of our time, our social legislation and all the measures which come from the same principle, have this effect—of which people are not sufficiently warned—to oppose the play of natural selection. This manner of thinking contains a great deal of truth. However, no defender of eugenics thinks of suppressing pity, or hygiene, to reestablish natural selection in its barbaric despotism. The efforts of humanity tend to utilize the natural forces for their own ends and not to let them act blindly. Also when the ideal of healthfulness and social progress is opposed to the ideal of perfection of race, because the first is contrary to the effect of natural selection, it becomes necessary to demand from artificial selection much more important effects, and especially those better regulated, than those which it produces among primitive peoples.

This we shall now consider in passing to the special question of birth. Even though we can lessen the effects of natural selection, we can much more surely intervene by artificial selection to favor the perfecting of the race and above all to prevent its degeneration. The point is to make good use of this power.

II.

In all times, man has tried to deal with the multiplication of his race. Independently of wars, famines, epidemics, whose destructive effects extend themselves over entire populations, suppression of infants already born, abortion, and prevention of births have been practised.

Eugenics, as well as economics, can, to be sure, tell us what the social interest demands. From the point of view of eugenics, the experience of centuries and of numerous researches teaches us above all that there are transmissible defects, reproduction of which must be avoided at all costs. These are notably the hereditary predispositions to insanity, to feeble-mindedness, to epilepsy, and to detrimental malformations; or again the acquired dispositions chargeable to the poisons of the nervous system, such as alcohol and the spirochete of syphilis.

Evidently one can not always be sure in advance of the effect of those influences which, acting in the mass, result in differences. Never-

theless there are individuals whose duty it is not to procreate, not to give birth to offspring, since the chances of deformity or mental deficiency are really too great. This duty is all the clearer when one is forced to conserve the life of those beings who, in other times, would have been condemned to a more rapid death by the brutalities of existence.

Apart from circumstances which justify and command abstinence, there are still others which can be drawn in very legitimately to limit the number of children; for instance, in the very crowded urban districts, the insufficiency of homes and the promiscuity cause an excessive mortality when families are large, and there are no means for choosing spacious dwellings. Finally, there are individual proprieties worthy of respect, for example, the care of the mother's health when she cannot stand numerous pregnancies, not to speak of the limits which can impose the legitimate fear of an undeserved loss, if a large family assumes a burden which surpasses its strength.

We cannot then accept the formula of an unfortunate equality, which would impose on all adults the obligation of having a determined number of children, any more than we would dream of recommending an unlimited fecundity. It is therefore necessary to discard formulas which are precise but too simple and to keep within the bounds of asking that each adult have children if he reasonably can. Each one, in fact, has the duty of transmitting the life that he has received, as well as of improving the value of that life just as those who have preceded have striven to do. And thus is imposed, according to the limits of one's means and capacities, the duty of perpetuating the family to which one belongs, the duty of contributing to the scope of one's country and to the progress of all humanity.

The formula is doubtless very vague; it is addressed to conscience, for it is conscience alone which is the judge of the degree to which the order has been obeyed. It is the same as when one appeals to the conscience of each one to participate in the defence of country or of national burdens. In this case, it is true that legislation enforces the moral obligation; is it not necessary that legislation also intervene in favor of the birth rate? The answer to this question is not doubtful; we can not omit a certain social organization capable of stimulating conscience and assuring the desired result, that is to say, the number of births which appear necessary for the whole population.

However, two objections have been made. One declares that before increasing the birth rate, it would be better to reduce mortality and, above all, infant mortality.

It is obvious that all measures capable of reducing mortality are good in themselves. But, since the remotest historical times, it has not appeared possible to lengthen the maximum of human life. We can

only hope to lengthen the mean duration of life. But that will not produce an appreciable increase in population in the countries where the number of births depends on familial foresight, when the parents determine, so to speak, in advance the number of children they will raise. Three years out of four in France, the number of births in one year is related to the number of infants who have died in the preceding; if many children die, they are replaced.

The second objection is that instead of seeking the striving for a great number of children, it is preferable to concern oneself about the quality. We have seen that the quality of population is in fact the principal aim of eugenics.

We shall consider successively the family and the nation.

In the family, when the number of children does not exceed the reasonable limit of which we have spoken, one can affirm that quality, far from being opposed to quantity, goes hand in hand with it. The case of the only child has often been tried. Numerous examples have also been cited of brilliant men who are among the young members of families, sometimes of very high rank.

As to the nation, she may claim a certain choice, a selection the importance of which we have mentioned in the first part of this paper.

But, admitting that those who carry defects are to be prevented from procreating, what sign enables us to recognize inferiority and superiority of qualities? It has been proposed to take wealth for an index. Numerous inquiries have proved in fact that in the slums of cities, among the individuals who have no care for the morrow, are found the greatest number of transmissible defects and the most afflicted children. On the other hand, manifestations of intelligence and various abilities have appeared more frequently in the children of well-to-do families than among those of poor families.

But here the influence of environment as well as that of education is considerable. Omitting the small part of the population which is composed principally of social outcasts, we can not but affirm that the innate qualities (we do not speak of acquired qualities) are less in the families of small income than those of large income, especially if one takes into consideration all classes of population, city and country, intellectual and artisan.

Reserving the elimination of undesirables, it does not seem that there is serious reason, from the single point of view of eugenics, to seek births in one class of population more than in another. The numerous statements which have been made on the retrogression or even the degeneration of families which have not renewed themselves sufficiently, tend on the contrary to promote the incessant mixing of social classes rather than their separation. When one considers the state of the population, one perceives great differences in the birth rate.

In France, the birth rate is generally greater in the country than in the city, greater in the mountainous regions than in the valleys, greater among agriculturists, sailors, fishermen, the colliers of the north, the heads of great industries, than in the middle classes, among artisans and especially among clerks. These differences explain themselves; they appear in the nature of things, and, for the moment at least, they do not carry any danger. We know that depopulation does not reach the towns, which are being filled unceasingly by an influx of inhabitants from the country. It is then the birth rate in the country upon which effort should principally be brought to bear; it is there that results can be gained most easily, at the least expense and under the best conditions from the point of view of hygiene, as well as from the point of view of eugenics.

Moreover, social action ought not to confine itself to facilitating the birth of children; it is also necessary to raise children up to a certain age. Questions of education, emigration and immigration are also questions on which eugenics has something to say, especially the question of immigration which has gained since the war an importance and character previously unknown in France.

Eugenics has also something to say on the psychological and moral side of the question of birth rate. Prevention of births, regarded as necessary in a certain measure, can be recommended only according to the means indicated by Malthus; the delay of marriage.

Fecundity of marriage, which one supposes sufficient to allow the maintenance of a healthy family well adapted to life, ought not to be fettered by an excessive fear of life, or by the fear of effort. No hope of the future can be realized except with a certain present sacrifice. It is necessary to make some personal sacrifices and to have hope in the future.

These sacrifices will be moreover fruitful for posterity. In what measure can they be shared; what profit can they yield for it? That is what the examination of the question from the point of view of economics will show.

III.

The economic power of a country depends primarily on its producers, that is to say, on those who by their work render natural riches serviceable.

Now we have already seen the loss of population since the war. The loss comes principally from the avoidance of marriage. During the war, many young men rightly wished to wait for the end of hostilities before marrying. Hence has resulted the increase of marriages in 1919 and 1920. The same phenomenon has been observed after all wars; it is easily explained.

But in spite of this the deficit is an important fact in our country and in Belgium. While the population of Great Britain has increased by 1,300,000 during the same time, that of Germany has hardly diminished and if it has diminished at all, we are still ignorant of it.

Imagine the state of the French population in fifteen years. At that time, there will be lacking, taking account of the mortality, 500,000 young men of the ages of 15 to 21 years, a loss which must be added to the 1,400,000 men of 18 to 50 years of age killed during the war, and who would then be 33 to 65 years old, as well as the 500,000 young men of the same ages who have died in the civil population in excess of the normal mortality. In all, about 2,000,000 individuals will be missing from the male population of 15 to 65 years.

In 1935 one sixth of those whose work must furnish the principal source of income of the nation will be lacking. In spite of the restoration of Alsace-Lorraine, which brings us 400,000 adults of 15 to 65 years but which also demands workers for its fields and iron foundries, it is certain that French production will be deprived of an important part of its active forces and that the economic life of the country will languish for many years if energetic measures are not taken without delay to ward off the threatening deficit.

Without doubt, one might temporarily appeal to foreign workers. Assimilable populations, however, can furnish only a small part. It will be necessary to have recourse to unassimilable races very different from ours, which will quickly furnish undesirable elements.

The deficit of male workers has caused the more general employment of women. But the women who work cannot be fruitful mothers. Feminine work will be only a short-lived mitigation.

For all time, since the infant brings care and pain as well as joy, maternity has been a cause of care and effort. Among primitive tribes which are displaced, it is necessary not only to nourish but even to carry these children. In our civilized societies, and especially in urban centers, where civilization is most refined, the burden is often very heavy. The difficulties of lodging, the hindrances of traffic, the care for appearance, which is applicable to children as well as to parents, the care for the health of the mother and all the complications of urban life; the laws for working women, the educational obligations and the impossibility, in poor families, of using the work of young children, make the maintenance of even a limited number of children sufficiently burdensome.

Formerly in poor families, who are the most numerous, the help which grown children gave to their old parents, compensated in some measure for the privations which they had caused at first. To-day, collective insurance is substituted for this kind of family insurance of previous times. In consequence, the child usually never brings any

repayment in exchange for what he cost. Also the care for his future causes the foresighted parents of our time to assure themselves of the excellent probabilities of his future establishment, which leads them also to restrain their responsibility. When the children may soon be an aid to the family, the burden is much lighter. Moreover one finds the greatest number of children among the people chiefly concerned with agriculture, and, in every country, in the rural populations.

However, the first obstacle to births is the possibility of raising the children. Doubtless this obstacle exists for many animal species and does not hinder their fecundity, but in those species there is no reasoning power, no foresight, no respect of life, at least in a degree comparable to that which may be observed in civilized human society.

A second obstacle, which does not exist in any degree outside of humanity, is the foresight of parents exercised beyond the time of growth of their children. It is not sufficient to have brought children into the world and to have raised them to an age when they have strength enough to answer for themselves; the environment in which they are placed must permit them to live. To understand the economic mechanism of the phenomenon of birth it is convenient to distinguish three orders of circumstances:

1. The means of keeping children alive during their growth.
2. The eventual means by which these children can live by themselves after growth.
3. The view of parents on these future circumstances.

It is necessary to understand here by means of life, the means of leading a certain kind of life; one can say in general that it is a kind of life at least equal to that to which the parents are accustomed. Often even, the parents desire their children to reach a higher stage of life.

But the means of living are governed in part by circumstances external to living beings and in part by the circumstances which depend on these beings themselves. The analysis of these circumstances makes up what is called the theory of population.

Long before Malthus, who formulated this theory, estimates had been made of the facility of increasing the human species, a faculty analogous to that of every other living species, when no limitation intervenes. It is wrong to censure Malthus for having employed the formula of geometric progression, since a simple reasoning founded on a not dissimilar hypothesis establishes it. Where Malthus appears to be mistaken is in his attempt to justify his law by experience or to deduce from one isolated experience the reason of progression. If he could have extended his observations still farther, he would have seen that this reason was not constant, and in consequence the progression was not geometric.

If on the contrary one keeps to the domain of hypothesis, as others

had done before Malthus, then supposing that nothing limits the fecundity of women, as a woman can bring into the world at least 8 children, and taking account of cases of involuntary sterility and physiological mortality, it is easy to understand that in thirty years a population not meeting any obstacle would increase in the proportion of 1 to 4 at least, that is to say, that it would be more than doubled in 15 years.

Malthus admitted that the population of the United States doubled every 25 years; a more rapid progression has been cited, that of the Hebrews passing through Egypt: 70 adults became 600,000 in two centuries, which means a doubling in exactly every fifteen years, and corresponds to the period of doubling of capital placed at interest of 5 per cent. a year. Every one knows what a fantastic sum is reached with a sufficient number of periods of doubling. If the doubling every 15 years had taken place since the beginning of historic times, the men living in our time not only could not find place on earth, but would even fill the space which separates our globe from far distant stars. The hypothesis which leads to an idea of constant geometric progression is not verified by facts. In reality the matter changes with the times because of obstacles which meet the indefinite multiplication of a species, for men as well as for all living beings. The interest of the work of Malthus is that this author has classified the obstacles and made a choice.

A second error, which is often made, consists in assigning also a general law to the development of the means of existence. These can only increase by following an arithmetic progression.

This supposed law has no theoretic foundation, even admitting that one works in a limited territory, since the production of subsistence depends on putting to work the means of production. In fact the means of existence have progressed much more rapidly in certain epochs than in others. In the nineteenth century for example, the population of the most civilized states increased more rapidly than during the previous centuries. There is then no general law for increase of population.

If one applies the formula which would recapitulate the theoretic movement of population, one would begin to say that population is developed in the measure that the means of living are developed, that there is a correlation between the two phenomena. But this vague formula is only pure tautology, since one can not conceive of a population which would develop without means of life. Such a formula can serve only as a preliminary to a true theory of population. In order to have a theory, one must indicate some mechanism for the relation between population and the means of subsistence.

The theory of Malthus tends to establish the fact that individuals,

according to nature, have an action weaker than the reaction exercised by it. Inversely, other theorists, before Malthus the mercantilists and populationists, after Malthus the advocates of patriotic fecundity, have claimed that, in certain limits at least, man could always obtain from nature what he needed to live. These two theories have been translated by picturesque formulas.

Where bread is born, man is born, say those who believe in blind fecundity and limited productivity. Where man is born, bread is born, answer those who measure the limitation of fecundity and have faith in the powers of invention.

In reality these brief formulas are too general: in some epochs, and countries natural increase of population tends to diminish production; in other cases the contrary is true.

In China, in India, when the population is increased to a certain degree, a deficient production results in veritable hecatombs of human beings, after which equilibrium is restored. In other countries where patriarchal life has given place to a complicated organization founded on the division of labor and the specialization of services, the means of production increase sometimes to such a point that production surpasses the needs. In this case, it is true, the conditions of existence of the people are in a mutual dependence, and this dependence gives rise to terrible conflicts.

In the human species, as in all living beings, death appears as an inflexible regulator of the interaction of the two factors of life: natural fecundity and nourishment. But, in the human species, the individuals are capable of foreseeing in some measure future events; foresight is the principal instrument of progress of the species and of civilization. Malthus has well noted this difference between the human species and others, and he has declared that for the brutal regulator of other species one may substitute that of reason. This has been expressed, in rather rude form, by a German economist, Julius Wolf, who sees in the universal decrease of the birth rate the effect of rationalism increasing life.

However, Malthus has not seen the importance which this factor will have and the danger which will result when this factor is capable of suppressing all the principles of life. He believed, on the contrary, that the power of instinct would always be stronger than the fear of overpopulation, and he impregnated the thought of his century with a dangerous pessimism.

But is it true that increase of population is necessarily a menace to the existence of this population? The facts answer for themselves. Not only has the 19th century seen the civilized nations increase in proportions unknown in the preceding centuries without these nations having suffered want; but, among them, the most rapid increase in wealth

has gone with the most rapid increase in population. In England at the beginning of the 19th century, poor laws imposed excessive burdens on the parishes, misery ruled and the lamentable state of the population at the beginning of the age of machinery justified later, in the eyes of Karl Marx, its attacks against the capitalistic régime. Since then the production of foodstuffs has diminished, and the population has quadrupled from 9 to 36 million (1911).

At the beginning of the nineteenth century an increase of population was feared in Germany as much as in England. Measures for restraining marriages were even passed in the legislatures of certain states such as Bavaria and Würtemberg. In order to have the right to marry, one had to show sufficient means. Thanks to these restrictive measures and to propaganda, the increase of population remained very slow—slower than in France—during a great part of the nineteenth century. Thus during the period of 25 years, 1847-1871, the number of inhabitants increased 13 per cent. in Bavaria, and 9 per cent. in Würtemberg, while they increased 17 per cent. in France.

Events happened which transformed the state of mind, and without doubt the faith in the future, without modifying the natural conditions of production, and the view changes. During a second period of 35 years, from 1871 to 1915, the number of inhabitants increased 34 per cent. in Bavaria and 27 per cent. in Würtemberg, while the proportional increase fell to 9 per cent. in France.

A good element of appreciation of the activity and the power of expansion of a people is furnished by the development of its exports, or, if we consider ten states for which we can give at the same time the proportional increase of the number of inhabitants from 1875 to 1913 and the relative progress of exports, a close relation between the two movements is proved.

PROPORTIONAL INCREASE BETWEEN 1875 AND 1913

	Population Per cent.	Exports Per cent.
France	10	80
Italy	29	145
United Kingdom	45	160
Belgium	54	237
Russia	65	260
Austria-Hungary	38	383
German Empire	58	380
Canada	103	423
United States	138	386
Argentine Republic	330	828

The two series of numbers vary in the same direction.

IV.

What is to be concluded from these results? Simply that the phenomenon is too complex to be analyzed in its entirety without going back to elemental facts.

Let us turn to the father of the family, for it is in fact upon the fathers of families that the birth rate of the country depends. We have said that this decision depended most generally on three factors:

1. The expense represented by bringing up a child to the time when it can care for itself.

2. The chances this child has of living effectively, at least in the conditions under which its parents have lived.

3. The view of the parents on this expense and these chances.

Other factors intervene also: considerations of health, well-being, etc., but we will concern ourselves only with those which are most general and least synthetic.

It is not regrettable that, in this grave question, reason is substituted for the most simple instincts. We must force ourselves to see only that which commands the true meaning of things.

At the origin of the problem of the birth rate are found two economic and one psychological fact. This last dominates the two others, particularly the second. Moreover the psychological fact intervenes only where the customs and legislation are directed by the sentiment of respect for life. For among the primitive peoples, abortion and infanticide excuse the parents from thinking of the future. They let the sexual instinct act freely, for they may cause to disappear the results of this action, sometimes, as in Sparta, with the illusory forethought of selecting the survivors.

In our modern society, these procedures are no longer permitted; they are supplanted by the prevention of births; that is left to the will of the parents who bear the burdens. But this will is guided by judgment and sentiment. If judgment is clear and sound, if sentiment is right, the voluntary action will be well directed; in the contrary case, it will come to evil. But the first condition, in order that the parents be not hindered by a too fearful foresight, that they may act in a sense best conforming to the good of society of which they are a part, is that they have a certain moral force, that they know how to sacrifice a little of their personal interest to the common interest—for maternity always brings some sacrifice, at least physical—and that they have confidence in the future. One may say that the question of population is above all a moral question. A certain optimism is necessary but this optimism ought to follow from facts.

It is always imprudent to ask too much of the sentiment of duty when one addresses a whole population. During the war, when invasion roused patriotism, it was necessary to impose military service by force.

Even when it is a question of the birth rate, when general education, when the comparison of military or economic power of the country shows all families a common duty, nothing better is needed.

However, although in this matter no sanction will be legitimate or efficacious, still it will be proper to facilitate the accomplishment of this duty.

What concerns provision for the future is one of the legitimate preoccupations of the head of the family. The movement of general prosperity must be such as to make the establishment of children appear easy.

It is sometimes said that there are fewer children in well-to-do families than in poor families. This is true in the sense that if the income of poor families increases, the number of their children tends to diminish. But it is not really exact for all categories of rich or poor families.

Let us consider for instance the French statistics of 1906 where the families were classified according to the number of children born in these families, whether living or dead. In the families where the marriage has lasted 25 years or more, the number of children per 100 families is equal to 303 among clerks and increases to 360 among their employers, 409 among laborers, and more than 480 among fishermen and sailors of the merchant marine.

If one classifies the employers who have been married more than 25 years and who are from 60 to 70 years old, one finds that the mean number of children born in 100 families is only 305 in the liberal professions, that it increases to 347 in commerce, 370 in agriculture, 385 in all industries properly so-called.

The relative situation of employers in agriculture and industry is not the same when one considers the marriages which have lasted less than 25 years. For the marriages having lasted less than 5 years, from 5 to 14 years, or from 15 to 25 years, productivity is greater in agriculture than in industry. Everything happens as if the heads of agricultural enterprises, after having had a determined number of children more rapidly than the chiefs of industrial enterprises, stopped sooner than the latter.

The details of professions permit even a distinction between the groups of similar industries. The number of children for 100 married men exceeds 390 in mines and quarries, in the "minoterie," in the textile industries, in the enterprises of building and of transportation, while it falls to 350 and below in industries of food production, in goldsmithing and jewelry. Thus it appears that in the great industries the employers have more children and in the small ones fewer.

Among the commercial professions, the smaller number of children per 100 families is slightly higher among the butchers; it is least among bankers and heads of financial enterprises, who form a sort of transition between industrial or commercial professions and the liberal professions.

Thus, among employers, productivity seems bound, in a certain measure, to the professional characteristics, but these are rather complex. On the one hand, the intellectuality of the profession, if one may so call it, causes a small productivity, so that the number of children per family is small in the liberal professions, in the learned professions and in financial enterprises, while the manual professions have a productivity relatively higher; on the other hand, the heads of great industries seem to have a productivity higher than that of the small industries and merchants.

Two factors act in a quasi-independent way; on the one hand, the intellectual character of the professions, which leads to late marriages and creates an environment little favorable to fecundity for reasons which it is not necessary to develop here; on the other hand, preoccupation with the fate reserved for the children. In great industries, the latter will easily find employment for their abilities and will obtain without too many difficulties situations equivalent to those of their parents, either in or out of the country. In the little enterprises, on the contrary (except in special instances, such as that of butcher, where the employment of the entire family is almost a condition of success), the father of the family does not look ahead without uneasiness to the future laid out for his children.

Certain of these characteristics will be found among clerks and laborers. Among the clerks, it is the young butchers who show the greatest productivity, then the inspectors and foremen, whose productivity seems to border on that of the laborers. The smallest number of children is observed among the clerks of stores, waiters in cafés, hotels and restaurants, office and public service employees. Among the laborers, the greatest productivity—more than 5 children being born in a family founded more than 25 years—is among smaller laborers and workers in spinning mills. The lace weavers, of whom a great number work at home, have a smaller productivity than the spinners (439 per 100 families against 540 among the spinners). Moreover, in agriculture, the domestic workers of the farm, generally lodged at the farm, have 395 children per 100 families, while the field workers proper have 426.

But the industries in which the workers have less than 4 children per family are numerous. Those who have about 350 children per 100 families founded more than 25 years are makers of wooden shoes, coopers, toy makers, saddlers, tailors, printers, metalworkers, electricians, jewelers and silversmiths, various workers in commerce, drivers and deliverymen. It seems that professions of small industries, and especially professions in cities, give the smallest figures. For the masons, day laborers, and people without profession, generally employed in the cities, there are 464 children born per 100 families;

among the workers of industrial service of the state, roadmenders, etc., the productivity exceeds 390 children born per 100 families; it decreases to 360 among the police, and customs employees, etc., to 350 for workers and sub-agents of the post and telegraph service. Finally, among personal servants, it decreases to less than 3 children born per family, always for the heads of families married more than 25 years.

On the whole, among laborers and workers in great industries where the work is relatively regular and abundant, when the agricultural work offers a real stability, when the dwelling is either in the country or in industrial communities consisting of laborers of the same class, productivity is relatively high. It is lowest among the small artisans, in the trades carried on in cities, also where the profession demands physical force to the minimum degree. It is also small where the persons classified as workers are confined to the category of clerks and especially where the conditions of employment, the conditions of lodging make preferable households without children or with few, rather than housholds burdened with children.

From the preceding statements, we remember that if the workers in general have more children than the employers there are not lacking professions where they have fewer. In the second place, for one as for the other, it is the great industries which seem more favorable to productivity and small industries less favorable. Naturally here the environment exercises a certain influence, the regions of great industry being generally other than those of small industry.

The preceding observations (they are illustrated by the pictures shown in the exposition rooms of the congress) confirm, although not entirely, those that have often been made on the relation between fertility and social standing. This being at once a function of income and education, the most fortunate categories are those where education is the most refined, or where the number of children is the most limited. On the contrary, fertility would be greatest in the poorest environments, in those where the kind of life is the plainest.

If, in a general way, this observation contains a great element of truth—this is shown by the comparison of districts of great cities classified according to exterior signs of income—there are reservations which must be taken into account. There is no doubt, for example, that employers are generally more fortunately situated than their employees, and yet they have notably more children than the latter. On the other hand, employees who generally receive higher wages than laborers, have fewer children than the latter. The question has often been studied, and it is important that new contributions be brought to it.

We will borrow for new indications recent statistics of France drawn up by the aid of family bulletins filled out in 1907 by a great number of employees and workers remunerated by the budgets of the state,

departments and communes (Conseil supérieur de statistique, bulletins 10 et 11: "Statistique Générale de la France," "Statistique des familles en 1906").

These functionaries have been classified according to the annual showing of the actual emoluments and, considering only those whose marriages have lasted more than 15 years, the number of children born per 100 families has been calculated:

TABLE

Annual salary in francs	500 at most	501 to 1000	1001 to 1500	1501 to 2500	2501 to 4000	4001 to 6000	6001 to 10000	more than 10000	Average
Marriages lasting 15 to 25 years.									
Clerks	277	241	259	245	223	231	239	238	237
Laborers	329	321	293	280	254	234	...	...	307
Marriages lasting more than 25 years.									
Clerks	330	301	305	280	264	264	261	286	285
Laborers	348	363	346	329	305	240	...	...	385

When all classes are taken together, the above figures are in accord with those which have been determined with the aid of the general census, either for clerks or for laborers or sub-agents of the public service.

Comparing now the numbers of children by classes of salaries, it will be noted that, among the laborers, the number of children diminishes regularly as the salary increases; among the clerks it diminishes until it reaches a minimum for clerks earning 2500 to 10,000 francs per year; it rises for clerks whose annual income exceeds 10,000 francs.

To complete these proofs, it is proper to remark that salaries and emoluments depend in great measure on the region or settlement where each clerk or laborer lives. Change in fertility is submitted to a double influence, showing that salary is only one of the factors involved.

The influence of environment becomes evident when we observe the families of limited classes of employees scattered throughout all France, generally in the rural communes the roadmenders and the rural police. For these employees, fertility is analogous to that of the population in the midst of which they live, greater in the regions of high birth rate, smaller in the regions with a low rate.

A similar investigation has been conducted among the clerks properly so called of prefectures and *mairies*. The personnel of the employees (not composed of boys, laborers, etc) has, in general, fewer children as the number of inhabitants of the city increases; the same is true of the populations of these cities. But a comparison between the fertility of these functionaries and general fertility shows that the first is less variable than the second.

In 1901, 100 families founded more than 15 years had 199 surviving children in Paris, 228 in cities of more than 500,000 inhabitants,

266 in the smaller cities. Among the administrative employees, the corresponding numbers are 183, 198, 215, or 92 per cent., 87 per cent. and 81 per cent. of the preceding. Employees have in some degree a specific fertility which depends less on environment than that of laborers. Results analogous to the preceding are obtained when the proportional number of sterile families is determined.

Among the marriages having lasted more than 25 years, the number of sterile marriages in 1,000 marriages, varies as follows, according to annual income:

Annual salary in francs	less than 1000	1001 to 1500	1501 to 2500	2501 to 4000	4001 to 6000	6001 to 10000	more than 10000	Average
Clerks	95	86	99	113	101	111	109	101
Laborers	70	74	91	98	100	...	...	78
And the proportional number of families having had more than 7 children:								
Clerks	56	53	41	33	26	23	52	44
Laborers	95	86	75	55	50	..	..	88

On the whole, the statistics of French families permit us to see in what measure fertility is bound up with the social situation. Numerous factors intervene: for instance, the heads of enterprises in the most industrial regions of the country—the north, the region about Lyons—have many children, more children per family than many other less fortunate classes. Among the laborers, the miners of Pas-de-Calais have likewise many children in relation to other laborers. In these two cases, the parents have no fear as to the future of their children. The great employer knows that he can easily establish his; the mine laborer knows that there will always be work in the mine for his.

This sentiment becomes general when one perceives continued progress everywhere, in the agricultural, industrial and commercial movements, and in the action of public authorities in favor of education, apprenticeship, exportation, emigration and public works. Confidence in the future is then assured. It is this factor which seems to have played an important rôle in Germany after the constitution of the empire and the war of 1870. But the two factors which we have just considered, a certain courage on the one hand and a certain optimism on the other, do not suffice always; it seems useful to ward off at first the obstacles which we have recognized, that is to say, to lighten the burdens which the maintenance of children causes parents. Here it is proper to proceed methodically. Since it is a question of financial participation, it is expedient to exert the effort where it is most necessary and to seek to obtain the maximum result from the sums used. It is humane to seek that the children brought into the world be raised under the best conditions for health. It is good not to go against the

natural course of things, to limit oneself to bringing simply the spark which sets fire to the pile.

V.

These considerations tend to favor the birth rate in the country. It is there that depopulation is raging—not that the birth rate is lower than in the cities (the contrary is true)—but because of the emigration from the country to the city. This is noticed when one compares the movement of the number of inhabitants in the French censuses of different periods, either in the urban or the rural population.

In 1856 the rural population was 26 million of the 36 million inhabitants in all France; in 1911, the number had fallen to 22 million, while the total population had increased to almost 40 million. The urban has been considerably augmented—almost doubled—passing from 9,800,000 inhabitants in 1856 to 17,500,000 in 1911. It has doubled also in the class of cities of more than 10,000 inhabitants.

It is useless consequently to seek to increase the population of cities by artificial means since they increase so rapidly by themselves that there is a veritable overcrowding in great cities. But it is necessary to increase the population of the country for reasons of hygiene, social stability, and also good economy, for it is there that children cost least.

It is in the country that the birth rate is already the highest, that one will find families best disposed to have numerous children. It is stated that the birth rate increases in proportion to the altitude. But, in France at least, it is from the high altitudes that have came the strongest currents of emigration.

Children cost much less to raise in the country than in the city. In the country poverty is most disquieting, which ought to cause farmers to assure themselves of a sufficient number of children capable of helping them by their work. There the growth of children takes place under the best conditions of health, especially if a system of maternal education is instituted; there one is near the foundation of the population, and there marriages are made with full knowledge of antecedents. Even as one rejuvenates trees from the stump, so the renewing of the population, necessary to combat retrogression, ought to be worked from the base. The best always come from a vigorous stock, as the best fruits and the most beautiful flowers spring from well grafted roots. In the cities, national effort ought to tend to improve lodgings, to facilitate rapid communication which will permit the largest extensions outside the crowded areas.

In France a law of July 14, 1913, gives to every family which has at least three children less than 13 years of age a monthly allotment for each child beyond the third under 13 years, while the child is living and has not reached the age of 13 years. The communes, the departments and the state share the expense. Another law, that of June 28,

1918, gives an important share of the state power to the departments which encourage births. This participation varies in inverse ratio to the richness of the department and in direct ratio to the number of families having more than 4 children. It carries at the same time the useful premium for the maintenance of children and a premium destined to assure a life-annuity to old parents or a capital to grown children.

In cities and industrial centers, numerous patronal associations have been formed to assure to laborers and clerks allotments varying according to the number of children. The treasury is kept filled by payments of heads of enterprises proportional to the salaries paid by each one of them. Thus the industrial head has no interest in employing a bachelor any more than a head of a family. The employees of the state and those of great private enterprises receive the same family allotments added to their salaries.

Finally, the fiscal legislation assures important exemptions to heads of large families and a surcharge to bachelors and families without children.

The tariffs of income tax—"impôts cedulaires et impôts globa"—takes account of the number of children; impôt globa surcharges the bachelors as well as married men without children. The inheritance taxes grant reductions according to the number of children living or represented, and surcharges when the defunct has left no children. Reductions are given on the railroads to members of families which have many children.

A severe law has been promulgated, July 31, 1920, against abortion and the sale of contraceptive measures.

An important movement thus exists in France which cannot but be favorable to increasing the birth rate. None of the measures adopted offers dispositions contrary to the legitimate exigencies of eugenics.

Let us add that the struggle against tuberculosis and the effects of venereal disease have gained much activity since the war; numerous dispensaries have been erected so that in spite of the increase of these diseases, one cannot find, as might have been feared, an increase in the special disability of children, excepting naturally those who were born or who passed their childhood in the regions invaded by the enemy.

The decline of the birth rate is a phenomenon which has shown itself in a great number of countries. The intensity of the movement is very different in different states; its effects depend in great part on the long or short duration of time since the phenomenon commenced to appear. The causes are almost the same everywhere; the means of combatting the causes are not known to be very different, although the action of moral influences depends naturally much on general mentality. As to the other influences, the experience of France can not fail to be instructive for all nations and for all those who are interested in this still conjectural science known as eugenics.

THE TRUE ARISTOCRACY [1]

By GEORGE ADAMI, C.B.E., F.R.S.
VICE-CHANCELLOR OF THE UNIVERSITY OF LIVERPOOL

STUDENTS of heredity are inevitably eugenists: they are forced by their studies to recognize that men are not equal, are not even born equal save—and possibly this is all that Montesquieu had in his mind—in the eyes of the law:

> That equal justice with indulgent face
> May shine unclouded on the budding race.

They are forced to see that men come into the world endowed with different powers; that these endowments have descended to them from their progenitors and as regards any power, it may be either from the paternal or the maternal side, in such a way that the different members of one family from the varying admixture of paternal and maternal attributes themselves differ in their powers; that defects tend to be inherited every whit as much as do positive or beneficial attributes; that where any particular defect, or, equally, any beneficial property, is present on both sides the likelihood is that it will show itself in the majority of the offspring and then, it may be, in an intensified form; that, therefore, if the race is to be improved, or even to be kept from deteriorating, steps are to be taken to encourage the mating of those with the better endowments and to discourage the mating of the defectives. Whether they join the Eugenic Society or no, they are eugenists. And—though in so saying I may shock my audience—as eugenists they are, if not themselves aristocrats, believers in an aristocracy. Their desire is that for the good of the race the best shall prevail, that we shall be led and governed by them.

Now from the earliest times up to the present, man—and woman too—has sought after, and indeed experimented over rule by the best. Before the tribal or clan system became established and for long generations after, the best woman either actively by her own will, or passively, by the superiority of his, became in the ordinary course of affairs the possessor, or possession, of the best, most virile man; and if in many parts of the world for a time, for reasons that are reasonably obvious, it seemed better to establish the matriarchate and the child became a member of its mother's and not its father's family, nevertheless, everywhere that system died out from its inherent weakness. The woman might nourish and bring up, but could not protect the family.

[1] An address contributed to the International Eugenics Congress held in New York in September 1921.

The man must be the huntsman and provide the food and, what is more, must be depended upon to defend the family. And once from the family the clan system developed, for purposes of defence as for aggression and enrichment of the clan, it was essential to choose the most powerful, most resourceful, and most all-round man of the tribe as leader. It matters little whether he fought his way to the top, or found himself there through recognition of his prowess and free will appointment by the other men of the tribe. Such was the first aristocracy.

And in those simple days, seeing that this best man had a practically unfettered choice and that the most comely and capable girl of his generation was his to secure, the probability was that their children likewise would be of superior quality so that they in their turn would make the best leaders. Wherefore, through experience men came first to be prepared for and then to accept a hereditary aristocracy, acknowledging the existence of first families and finding it for the good of the tribe that an Amurath should an Amurath succeed, and Harry, Harry.

Now entertaining as it would be, more particularly here in New York, to trace the further development of this hereditary aristocracy until it came to include emperors and kings, and a succession of grades of nobility, and reached its fullest elaboration in the feudal period, I am not going to do this. All I want to impress upon you is that the elemental idea of an aristocracy is sound and natural, but, granting this, that, thus far, however successful we may have been in the practical application of the idea to the establishment of the four-footed "aristocrats" of the turf and trotting ring, and in the breeding of animals possessing superlative speed or power or form or mass of flesh, be they racers or Clydesdales, greyhounds, red Berkshires or Plymouth Rocks, we have, to speak frankly, made rather a mess of it among ourselves, until to many the idea of a hereditary aristocracy of any order is intolerable, an opinion strengthened by the observation that those who most loudly proclaim their aristocratic relationships are most often such as those aristocratic relations least care to acknowledge, the said claimants having family and beyond that nothing of worth. Wherefore one has come to doubt the worth of family.

And yet so perverse is humanity that those to whom aristocratic régime is most abhorrent cling in their innermost hearts to their family tree and either pride themselves on the possession of this or that ancestor or upon the mingling of this or that stock into theirs. I may note incidentally that here, in this great republic, genealogy is pursued to an extent unknown elsewhere. While those unfortunates who, to put it generously, can not look down their family tree, look up to the fair tree that is to spring from their loins and see its future growth to overtop its neighbors.

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In other words, the love of good family, either as something already attained or as something to be attained, is inherent in the human race. We seek higher things. Through all the centuries we have been eugenists in principle, even if in practice we have made a painful mess of it. For in practice all these centuries we have mistaken accidentals for fundamentals, have elevated immediate advantages above future well being. With royal and princely families the stamina and capacity of the bride to be has been the lesser instead of the prime consideration: the choice of consorts has been limited to a parlous not to say sinister extent, and the political importance of alliances between royal families has too often led to matings that could but result in a deteriorated progeny. And where, as in France, among the people in general, there is a well established opinion as to the importance of carefully selected matings, there also the quality of the stock has been subordinated in general to the size of the "dot": more has been thought of the property that will come into the family than of the richness of the blood that will be commingled. The results on the whole have not been any more satisfactory than have been those of the "mate as you please" system which obtains in Anglo-Saxon countries.

Now, with the twentieth century, we have awakened to the fact that the principle of "laissez faire" is as pernicious in the matter of marriage as it is in politics. Our eyes have become unwillingly opened to the fact that with the improved well being of the people and the very material lessening of the death rate it has come to pass that the multitudinous children of defectives and those who both physically and mentally are of the lower order are forming the bulk of our population, since those who are pre-eminent, intellectually and bodily, marry late and have small families. In other words, the social conditions of the present day are such as to favor the preponderance of what are from every point of view the lower classes, the survival of the unfit and the inevitable deterioration of the race.

But here is the difficulty. Among what we regard as the lower classes are included not a few families of good quality, both mental and physical, which through accident, as for example, illegitimacy, or the fortunes of war, or the premature death of the breadwinner, are in poor circumstances, occupying a menial position. Circumstances have been against them. Thus it follows that from time to time we encounter men sprung from the ranks who, given the opportunity, come to the front and make their mark in the world of commerce or of intellect. Even when the feudal system was at its height and when caste was most repressive, men of this order could occasionally, although rarely, force their way to the front, either through the Church (although then they still more rarely founded families) or through their military prowess as leaders of mercenary troops, or, like the Medici,

through the city guilds and the power of the purse. The last, industrial, century, with its broad middle class forming a bridge between the working and the ruling classes has seen this becoming so frequent a phenomenon that it, with the equally obvious but, I think, less frequent examples of the decadence of families that for generations have been held in high repute, has led to what was a wide spread conviction, namely, that birth and breed count for little and that fortunate upbringing and environment are the more important factors in a man's success. Even to-day this opinion is held by a large number.

Now I am not going to discuss the still debated problem as to the extent to which environment modifies the individual and so the family and the race. I am going to satisfy myself with the well established principle or biological law, that by cautious selective mating, qualities of very various orders, in man, equally with other animals and with plants, can be strengthened and intensified. I do not say that they are capable of indefinite expansion. We have, indeed, no proof that this is so. Rather the evidence indicates that we can by selection lead up to what I may term optimum development—development best suited to the size and state of other parts and properties of the individuals of any particular species in its particular environment. Developments in excess of this proper correlation may, it is true, show themselves in individual members of the species, but, even when mated with others showing a similar excess, the progeny do not exhibit the excess. Let me give an example of what I mean. By careful selection, proper feeding and surroundings, we can gradually improve the laying properties of various breeds of fowls, but this only up to a certain point. Occasionally, it is true, we encounter individual pullets of a particular breed who yield it may be ten or twenty eggs per year above this established optimum. But now it is found that if we mate the male and female progeny of such excessive layers, they only produce at most the optimum, indeed, most often less than the optimum. It is as though the exhibition of a particular property, above a certain limit, exhausts the individual in other directions and leads to deterioration rather than to improvement.

I am not suggesting therefore that, the environment remaining unaltered, man, as man, is by selection capable of indefinite improvement. The most I urge is that to-day so large a proportion of human individuals is so far below the optimum that there is vast room for improvement: that under modern conditions through the larger families of the unfit the race is deteriorating and not improving, and that it behooves us to take active measures whereby to encourage the selective mating of the best and the production of those endowed with sound and useful qualities.

Now the function of societies for the promotion of eugenics is, I

hold, to promote this better mating, but, if I may speak bluntly, I am impressed with the fact that they have begun at the wrong end. Passing in review the pages of the volumes of the *Eugenics Review* what I find in them is, with all due deference to the high-minded ideals of the leaders of the movement, a vast amount of spade work in the establishment of the broad principles of heredity, a profound appreciation of Mendelism, sundry lamentations of latter day prophets, such as the most witty, albeit most doleful, dean of St. Paul's, upon the downfall of Jewry, or more accurately, the sure and certain deterioration of humanity, the qualified approbation of sundry destructive procedures such as restriction of criminals and segregation of defectives as adopted by certain states, but with this singularly little constructive policy: or if I may so express it, a ha'porth of bread to an intolerable deal of sack.

Now possibly the leaders in this movement are acting most wisely in devoting their time to making sure the foundations, and in the first place driving home to people the extent and the dangers of national degeneracy. Possibly the fear of degeneracy is in this matter of eugenics the beginning of wiser courses. Nevertheless, I can not but feel that usually in this world with the planning of foundations there is requisite some considered design of the building that is to rise upon those foundations, and that design is here largely wanting.

As for what I have just termed the destructive procedures, I have strong doubts as to their politic value. Some experience of the world has taught me that while a majority of mankind is law-abiding and will obey commands of the order of "Thou shalt not," there exists a very considerable minority to whom such commands act as a stimulus or incentive to set them at defiance. Grave as are the consequences, prohibition of marriage on account of the existence of venereal disease in one or other of the contracting parties will not put a stop to such marriages; nor will segregation of the feeble-minded prevent those feeble-minded seeking or consenting to illicit conjugation whenever occasion arises. The ordinary every day individual, thinking only of matters of the moment and careless of the future, will not hesitate to transgress laws which interfere with his liberty. The only laws interfering with personal liberty that are generally kept are those the transgression of which is followed by a personal penalty, such as that of the judicial murder of those committing murder. Public opinion is not as yet ripe for the infliction of castration upon those who, for instance, enter into the married state while knowingly sufferers from venereal disease, richly as they deserve it.

What is more, even granting that by these and like methods we reduce the number of defectives, thereby we only advance the average quality of the race: we do not actively increase the number of those of

first-class ability. This I am glad to see is being recognized in the United States.[2] The need is to promote the propagation of the best in the race. And it is to show how this can be accomplished that now I want particularly to direct your attention.

In the first place, I would lay down that encouragement is more effective than punishment; that the "thou shalt not's" of the decalogue and older dispensation have given place to the blessing of the positive virtues of the new; in the second, that the war has supplied the solution.

Making enquiries as to the proportion of rejections from the British Army, to compare with the Canadian figures, it was my good fortune to be promptly appointed by my late colleague at Montreal, then minister of national service, now British minister in Washington, on the scientific committee of the Advisory Council of his ministry—and as a member of that committee it fell to my lot to oversee the analysis of the physical state of the manhood of Great Britain in the last year of the great war. That you should understand the significance of this analysis and of the figures presented to us it is necessary that I enter into certain explanations.

I may remind you that service in the British Army had at first been voluntary and then as the situation and needs became more and more grave, first conscription became what I may term persuasive with "combing out," and then in 1917, became generally compulsory, all able-bodied men between the ages of 18 and 51 being called up. In the middle period, large bodies of men employed in industries of primary importance to the nation had been directed not to join the colors. Their industrial services, indeed, were deemed of such importance that then began that undue augmentation of wages which has been at the root of the present economic trouble in Great Britain.

For generations prior to 1914 men volunteering for military service had, prior to acceptance, to undergo medical examination into their physical fitness. Hitherto, this had been conducted by adequately trained officers of the Royal Army Medical Corps. The war with its sudden augmentation of the army and need for battalion medical officers and ambulance and hospital corps at the front and at the base found the corps all too small. Every well-trained man belonging to it was needed at the front along with many times the number of surgeons and practitioners enrolled out of private life. Inevitably the younger and more vigorous of these joined the army and went overseas, leaving behind the older and less vigorous who now were called

[2] "While the need of cutting off defective and degenerate lines is becoming widely recognized and is being met with legislative enactment, there is as yet little organized effort to direct the evolution of lines among our mediate and superior classes."—W. E. Key, *Journal of Heredity*. 11. 1920. 359.

upon not only to take over the patients and practices of their absent colleagues, but also, without adequate training, to undertake for the government at different centers throughout the country the routine examination of would-be recruits for the army. The results were what might be expected. Many were passed for service who were totally unfitted, who subsequently had to be weeded out of the army at heavy cost to the nation; there were repeated cases of wide and inexcusable differences in the findings of successive examiners, damaging criticisms in the public press, and development of a feeling of public insecurity. As a result the government determined to take from the Royal Army Medical Corps the responsibility for examining recruits, and, under the Military Service Act of 1917, it withdrew the matter of "categorisation" from the army, placing it under the control of the minister of national service, who forthwith proceeded to organize the physical examination of the men called up, placing the task in the capable hands of Dr., later, Sir, James Galloway, and a small but carefully selected committee.

The country was divided into regions, commissioners were placed in charge of each, with deputy commissioners and a staff under them. The deputy commissioners were brought together and trained so as to employ common standards and arrive at a common agreement regarding the categorisation of border line and doubtful cases: a clear and admirable code of directions was placed in the hands of every member of the new boards and, in short, every endeavor was made to conduct the physical examination from one end of the country to the other under a single standard. Thus, at the end of 1918, it fell to our committee to direct an analysis into the results obtained from the physical examination of close upon two and a half million men conducted under these standardized conditions.

Here it will be out of place to detail the difficulties encountered in analysing and weighing the figures before us. Those are to be found discussed in the Government Blue Book containing the report of the committee drawn up by Dr. H. W. Kaye as secretary to the committee.[3] Nor again am I going to dwell upon the alarming picture this report disclosed of the wide spread physical unfitness of the adult male population of Great Britain. That is apart from my present object. What is to the point is that for the purposes of arriving at the significance of the figures under review, Professor Arthur Keith, F.R.S., the distinguished anatomist and anthropologist, who was a member of the

[3] Report upon the Physical Examination of men of military age by National Service Medical Boards from November 1, 1917, to October 31, 1918, London. February, 1920. Those to whom the British Government publications are not easily available will find an abstract of some of the main findings of the report in the *Lancet* (London), Vol. 1, 1920, pp. 557, 726 and 780.

committee, pointed out that the established "categories" of the army, A, B, C, D,[4] could be translated into "Grades" I to IV in the terms of the polygon of frequency.

Let me explain. It was found that a thousand Cambridge University students, measured for stature, arranged themselves in a significant manner. (The same has been found true of other exact human measurements). In this particular set of men, those measuring more and less than this tailed off inch by inch on either side of this mean with striking symmetry.

There were roughly, within a few digits, as many men of stature 1 inch below this mean as there were men 1 inch above, and, from this mean of 5 feet 9 inches, those more or less in height formed classes

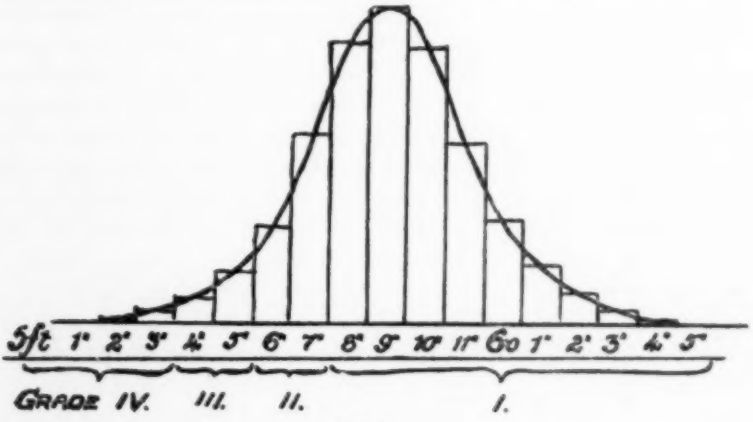


FIG. 1.

tailing off in a curiously balanced manner. On such a "polygon of frequency" as shown in the diagram one can construct a curve of frequency.

Keith pointed out that the mean class (that of 5 feet 9 inches) together with all those above the mean and the class just below the mean, together constitute 70 per cent. of the total, and he assumed that the combined measurements employed to determine a man's physical fitness should follow the same general law. Along these lines he laid down that the active service group should include all average men and those

[4] Category A. Men physically fit for active service at the front.
" B. Men able to undergo a considerable degree of physical exertion and with fair hearing and vision, but in consequence of partial disabilities unable to stand severe strain; fit for any form of service overseas save active service at the front.
" C. Men who in consequence of physical disabilities could not undertake marching but could be employed for the less arduous and sedentary occupations.
" D. The rejected, unfit for any form of military service.

above the average in physical fitness together with those just below the average, and that therefore we should expect in a reasonably healthy sample of the male population:

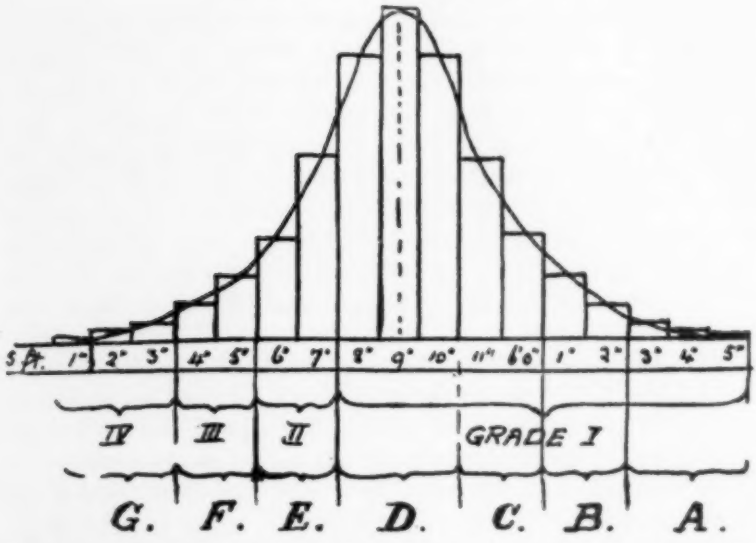
700	out of each	1000	should be	"A"	men, belonging to	Grade I.
200	"	"		"B"	" "	Grade II.
75	"	"		"C"	" "	Grade III.
25	"	"		"D"	" "	Grade IV.

As a matter of fact these index figures of Professor Keith showed themselves close to the mark and most useful for purposes of comparison. Certain mining and agricultural districts indeed yielded well above 700 per 1,000 Grade I men. Scottish miners between 18 and 21 years of age yielded 80.62 per cent., young adult Scottish ironworkers 86.18 per cent. But while in general mining and agricultural districts yielded the expected 70 per cent. or thereabouts, the great towns afforded conscripts gravely below the standard. I take the 18-year old group as that which should physically be fittest, least affected by the deleterious influences of industrial and commercial or sedentary occupations. Even in this most favorable class, studying the results obtained in different areas, cities like Liverpool and Birmingham yielded 49.5 and 36.0 per cent. Grade I men, respectively: they were lower in the big manufacturing towns, for example, 1,000 youths in Burslem yielded only 270 in place of 700 physically fit for active service, in Dudley only 219. So serious a state of affairs was disclosed that it is of first importance to the nation to discover whether this is due to progressive deterioration of the town-bred and industrial stock or whether the effects of unfavorable environment on the growing individual are wholly responsible. For myself I cannot imagine the stunted and anemic mill-hands of Lancashire bringing forth offspring which under the most favorable environment could develop into men and women of full stature and all round physical capacity.

This, however, is away from my immediate point. What is of first importance is that the report of the Ministry of National Service has demonstrated that it is possible to establish a series of tests for the exact and uniform measurment of physical capacity and, having these, to grade those who undergo the tests into a succession of clearly defined classes.

For eugenic purposes, however, it will never do to take over the national service grading. We do not want to clump together the average, those just below and all above the average into one common group. That was well enough for determining men capable of becoming front line troops. But we need to select the best, not the average. Thus as I suggested three years ago,[5] just as the army for its purposes recognized

[5] "The Physical Census," an address delivered before the Medical Society of London, 25 November, 1918, and printed in the *Transactions* of that Society, as also in the *Canadian Medical Association Journal*, September, 1919.



three categories below the mean, so for our purposes we might well establish, as shown in the diagram, three classes above, making in all seven classes.

In this way Class A would contain the very pick of manhood, a select class of some 2 per cent. of the whole body, men of exceptional all round physical development; Class B, men thoroughly well developed, who might, only in some one respect such as stature, fail to be included in Class A; Class C, good all-round men distinctly above the average; while Class D would represent the large group of ordinary average men, and Classes E, F and G would correspond with Grades II, III, and IV of the National Service system (Army categories B, C, and D.)

This, however, is only half the matter. Neither Great Britain nor any other European nation made any attempt to pick out from the start the men most likely to develop into good officers and non-commissioned officers. For that they depended upon the actual test of army conditions. In other words, not a single European nation applied any test of intellectual capacity. It was left to the United States to apply this eminently rational procedure to the army she raised for overseas service.

Scarcely had war been declared by the United States in the Spring of 1917 before the American Psychological Association brought together its members to consider how they might serve the country in the emergency.

It should be explained that the pioneer work of the late Professor Alfred Binet, of the Sorbonne, had made a greater impression in North America than it had in France or Europe in general. In 1905 Binet had shown that it was possible to devise reliable tests of mental capacity applicable for each year of age of the developing child, so that, ac-

cording to the way a child responded to the tests, it might be accurately graded—e. g., a child of the actual age of 10 years might be shown to have the mental capacity of, it might be, the ordinary child of 12 years of age, or, on the other hand, only that of a child 5 years old. This method had been extensively tested by various American psychologists, more particularly for the elimination or segregation from the public schools of those mentally defective. Important advances in the methods of testing and evaluating the tests had been represented by the Goddard revision of the Binet scale, the Yerkes-Bridges Point scale and the later and fuller Stanford revision of the Binet scale, for which Terman was largely responsible.[6]

The chief purpose of the psychological assistance originally offered to the Army Medical Department in the Spring of 1917 was the prompt elimination of recruits whose grade of intelligence was too low for satisfactory service. But when in the autumn in order to test the value of the methods of the committee they were applied to enlisted men of all orders in four selected cantonments the results obtained tallied so closely with the more slowly acquired judgment of the officers in command as to warrant the recommendation "that all company officers, all candidates for officers training camps and all drafted and enlisted men be required to take the prescribed psychological tests" and in January 1918 the recommendation was acted upon. Every soldier was tested and assigned an intelligence rating on the basis of a systematic examination. Through this system men of superior intelligence were selected from the first for advancement for special posts and particular types of military duty, or recommended to enter military training schools. A school for training in military psychology was established, and by Armistice Day, in November 1918, the psychological personnel attached to the Army Medical Department had risen to 120 officers and 350 enlisted men together with some 500 additional clerks engaged in the examining service in thirty-five camps throughout the country. The tests had been applied to 1,726,966 men, of whom 41,000 were officers; 7,800 men had been recommended for immediate discharge on account of mental inferiority; 10,014 had been recommended for labor battalions, and other service organizations on account of low grade intelligence. Men qualified to be non-commissioned officers and candidate-officers on the basis of satisfactory intelligence scores were picked out within forty-eight hours of their arrival in camp.[7]

[6] There is abundant American literature on the subject, for which consult more especially the "Manual of Mental and Physical Tests" by Whipple, and "The Measurement of Intelligence" by L. M. Terman, (Houghton, Mifflin Co.) Boston.

[7] For further particulars see "Army Mental Tests" compiled and edited by Clarence S. Yoakum and Robert M. Yerkes, New York: Henry Holt and Company, 1920.

The new procedure must have proved itself eminently serviceable and practical to have become applied universally to all recruits within six months of its experimental introduction into the army. As a matter of experience, the rating awarded to a man as a result of the tests was found to furnish a fairly reliable index of his ability to learn, to think quickly and accurately, to analyze a situation, to maintain a state of mental alertness, and to comprehend and follow instructions. The score was little influenced by schooling or, more accurately, it was so influenced,[8] even though at the same time some of the brightest records were made by men who had not completed the eighth grade of the U. S. public school system.

It is a not uninteresting coincidence that the American scale was worked out in percentages, 100 being taken as the highest available mark, and that here also seven classes were recognized, namely:

A. (rated 96 per cent. and over). Very superior intelligence—usually earned by from 3 to 5 per cent. of a draft—men of pronounced intellectuality of the high officer type (if endowed also with capacity for leadership and qualities which admittedly are not revealed by the standard tests).

B. (80-95 per cent.) Intelligence superior but not exceptional. Obtained by 8 to 10 per cent. of a draft—men of the officer type and many non-commissioned officers.

C. + High average intelligence, comprising from 15 to 18 per cent. of all soldiers, with a large amount of N. C. O. material. With power of leadership men of this grade are fitted for commissioned rank. (The three C groups include those grading from 40 to 79 per cent.)

C. Average intelligence, the main mass (25 per cent.) of soldiers. Excellent "private" type.

C.— Low average intelligence (about 20 per cent. of material). Men satisfactory for work of a routine nature.

D. (20-39 per cent.) Inferior intelligence (15 per cent. of all soldiers). Fair soldiers but low in rank. Slow in learning with little initiative, rarely attaining higher rank than "private."

E. (0-19 per cent) These along with D— are of very inferior intelligence. D— men were considered fit for service. Some E men were placed in labor battalions but most were rejected. D— and E men were below ten years in mental age.

It deserves emphasis that the tests only indicate intelligence. They do not measure loyalty, bravery, power to command, or those emotional traits that make a man "carry on." Nevertheless, next to physical fitness, intelligence is the most important single factor in military efficiency.

[8] Thus while stating (p. 22) that the rating was little influenced, Yoakum and Yerkes give a table showing that there was a steady increase in intelligence in the students of the successive years at the University of Illinois; 91.4 per cent. of the freshman class were rated in the two topmost grades, as compared with 92.3 per cent. of the sophomores, 94.1 of the juniors and 95.9 of the final year.

Thus, to come to the point, the great war has in one respect been of service: it has afforded material for testing on a great scale and demonstrating the possibility of devising accurate and satisfactory methods of measurement of physical and intellectual capacity. Henceforth there can be no question as to the practicability of establishing standards of efficiency and quality. Nor is there any reason why these tests be not applied to women as to men. The method has been tested and found of proved value.

And what I would urge is that here at last we have before us the obvious line of practical work for eugenic societies and the eugenic movement in general. Encourage the best! Either organize, or make the state organize in every district a trained staff provided with a well-equipped set of rooms for the routine testing of every young person whether male or female, who has reached the age of eighteen years. I say eighteen because, while intelligence does not, so far as we can see, improve beyond the standard which some are capable of reaching at the age of sixteen, undoubtedly there are slow developers whose intellectual capacity, below normal at this life period, improves after the age of sixteen, while in general physical capacity is at its best at the age of eighteen, and from other practical considerations this latter age is the best for purposes of record.

Do not make the tests compulsory. What indeed is the need to trouble about the average man or woman. We want to pick out the best in the community. And having picked them out publish their existence in the world. Establish an annual record of all the A I youths and maidens of the year, "A" standing for the first class in physical fitness, "I" for the first class in intelligence. Nay, I would say publish the list of all who attain to "A" and all who attain to "I" standards. There are positions in which physical fitness is sought after irrespective of mental capacity, and vice versa. Like considerations might favor the publication also of all the "B" and the "2" classes, for both are well above the average.

Think of the effect of such a publication. Think of the start in the world it would give to a man or woman to be able to refer to his or her record as belonging to the A 1 class; think of the status it would give him or her for the years to come, of the preferential treatment that would be afforded when applying for posts. Consider the preference the A 1 man or woman would have in marriage, how parents before giving their consent would require that he who sought their daughter's hand should produce his eugenic society certificate and show where he stood in physical and mental capacity; of the advantage the A 1 man would have in seeking the hand of a desirable damsel. Think how in years to come these annual publications would establish the good strains, the desirable families with which to become associated, how in short they would become the human stud book.

But, it may be objected, the man who at eighteen is rated as A 1 might from a variety of causes—tuberculosis for example, or grave accident such as fracture of the skull, or acute infectious disease, or venereal disease, or overwork, mental or bodily, fail to maintain his rating: the fact that in youth he was A 1 is no assurance that by thirty he is not an undesirable. Quite so. But this is by no means an insuperable objection—once the published record appeared, the first-class man would come to ask to have his rating renewed so long as he continued to be first class, say every five years, at 23, 28 and 33 years, and if he could not produce certificates of continued efficiency this would tell against him, unless he could give a satisfactory explanation of the cause of his reduction in rank.

Now the indications are that there is a natural, or, under present methods of life, an expected reduction in physical efficiency after twenty-five years of age and of mental alertness after thirty-five or so. These would have to be taken into account.[9] So far we do not possess data sufficient to establish what may be termed the normal curves of physical and mental efficiency for successive age periods after eighteen.[10] The accumulated statistics of A 1 men and women would supply material for the establishment of a table of what may be termed age-efficiency, mental and physical, for successive years of age from fifteen to fifty.

Here would be the ideal Debrett—here the establishment of a veritable aristocracy of the country, personal and hereditary. I ask you to think over it. The scheme is not impossible. It only needs to be started to show its usefulness. Nay, more, it would be self-supporting. Men and women of good quality would gladly pay a moderate fee to cover the cost of the examinations and for the cost of announce-

[9] See Adami, Loc. Cit.

[10] A beginning has been made. The Bulletin of the National Research Council on the "Intellectual and Educational Status of the Medical Profession in the United States Army" by M. V. Cobb and R. M. Yerkes (Washington, February, 1921) shows (p. 483) that there is no significant decrease in intelligence rating (of officers) rating from 20 to 26 years but thereafter to the age of 60 there is a marked decrease. The relations of intelligence to age of 95,742 medical officers examined at Camp Greenleaf gave:

Age of	25 (303 cases)	277
"	30 (334 cases)	258
"	34-35 (257 cases)	262
"	40 (305 cases)	255
"	44-45 (241 cases)	235
"	50-51 (131 cases)	223
"	54-55 (63 cases)	212

These figures indicate a slow descent from 25 to 35 and after that a more rapid one.

ment and publication of their superior merits. Compare the cost of encouragement thus of the best to that of hunting out and suppressing the unwilling worst. Again, I say it only needs to be taken up seriously and started to demonstrate its value and desirability. Here at last we aid and encourage the improvement of the national stock, the advancement of the quality and well being of the nation through the establishment by scientific and democratic means, irrespective of wealth and influence, of the real aristocracy of the nation.

SCIENCE IN FRANCE

By Professor PIERRE BOUTROUX

THE very title of this article seems to imply two preliminary assumptions which many modern readers will be inclined to question. First, that in this time of technical achievements and highly specialized work, there still exists such an entity as "Science," distinct from the various sciences. Second, that when industry, commerce, politics, even literature, become more and more international in their scope and character, science may still be considered as some sort of national enterprise.

I have no intention to ignore the questions thus raised. But the best way to throw some light on them is precisely, I think, to fix our attention on some particular case, on some concrete country, and to observe whether the different scientists of that country have or have not something in common, some definite standards and ideals which may be called their own.

Such a problem has little or nothing to do with the enumeration of the notable discoveries achieved in such and such country. A true discovery, being the mastering of some new piece of universal truth, *must* have an objective and therefore an international value. The greater the discovery, the more impersonal it is. So that the prevailing custom, which makes us call discoveries and laws of nature by the names of persons is, in point of fact, just as misleading as it could be.

But the objective discovery is not all of science. It is only the end of it, the result obtained by scientific work, that is, by human activity. Furthermore, any single discovery has to be linked and compared with other discoveries and hypotheses: as soon as it is acquired, it becomes part of a theory which is largely contingent and human. Now, on the one hand, it is a well known fact that there is no sure method, no marked and traceable path for obtaining scientific discoveries; only by trying and trying over again, by toiling, approaching questions from various sides, opening our minds to inspiration and intuition, may we hope to fall upon the idea which will lead us to discovery. *Theories*, on the other hand, are always provisional and changeable, and there is no absolute standard to fix their value. This being so, is it not to be expected that the type of education a man has been given, the habits of mind which he has acquired in life, the models which he finds before him, the general ways and inclinations of his surroundings, will have a notable influence on his methods and on his work?

There are surroundings, there are countries in which, for some reason, some kind of work is more likely to succeed than in others, in which some discoveries have a greater chance to be arrived at, in which some types of scientific system are more likely to spring up. The influence so exerted is felt even by foreigners and it is worth while studying it. I said a moment ago that to associate names with discoveries is a task void of any real interest. But, on the other hand, it is not uninteresting to learn that the Wright brothers achieved decisive success and gave a great impetus to aviation while they were working in France. To take a more convincing example, it is interesting to know that the great scientist and philosopher of Hanover, Leibniz, did come to Paris as a young man and found there the inspiration and the ideas which led him to his first discoveries.

What was it that Leibniz and many other scientists of his time and other times have found on French soil more than they did elsewhere? What are the qualities that have made French scientists often successful and given them followers all over the world? On the other hand, can we trace any characters of scientific *theories* which are especially appreciated by the French and are generally apparent in their productions? Such are the questions which I would try to answer, considering first the tradition of scientific work in France, and second its present condition.

* * *

The traditions upon which modern French science is based were laid down during the first half of the seventeenth century.

This does not mean that science was not an important factor in ancient French civilization. As a matter of fact, the part played in the first revival of science by the University of Paris, the oldest in the Western World, has been exceptionally brilliant. However, the merits of the work then done are not exactly of the type which can be contemplated from a national standpoint. Science in the Middle Ages was highly international, more international than it has ever been since. Besides, the brilliant era started by the old University of Paris was followed by a period of comparative obscurity. Science was again at a standstill until the revival of the study of the original Greek treatises gave it a new impetus. Later still came the time when a reaction against too close an imitation of the Greeks was deemed desirable and when it became apparent that new ways should be tried. Then it was that the national character and national ideal had an opportunity to show themselves. This happened in France at the very moment when French literature, French art, French culture generally, reached their highest point. The time of Corneille, Molière, Bossuet is also the time of Descartes and Fermat. There is a deep significance in that fact, and it is not through a mere coincidence that a man like Pascal

was as famous as a physicist and mathematician as he was as a moralist and as a writer. Pascal, by the way, might be regarded as a fair representative of the French scientific spirit of his time. Descartes, however, is the leading figure. Descartes stands first, not only because his influence has been the widest, but because he was the man who realized fully that the old conceptions were to be changed radically. He was the man who had the clearest and most prophetic vision of a new type of science.

But, before trying to define Descartes' position, I wish to make a few preliminary remarks.

In the system of knowledge which forms a science, two kinds of elements are fundamental: First, the logical deductions or constructions, which combine abstract principles, notions or statements; second, the facts, which are either experimental facts or such facts as may be found in pure mathematics.

The logical aspect of science had been dominant in the work of the Middle Ages. During the later period of its evolution, at least, scholastic science was based chiefly on logical constructions. Such a science will not be worthless if it happens to rest upon solid foundations. But it is likely to become, in most cases, a purely formal and abstract system, which will care little about the value of its material as long as its deductions are correct and consistent. The weakness of scholastic science was that its aim was not definite, its development was not guided. Logical combinations, worthless for any practical purpose, without any appeal to human intelligence at large, may be piled up and piled up and form an endless chain. Huge books have been filled with them, the aspect of which is somewhat terrifying nowadays. It took a man's life to write one of these books and years to study it. And the trouble was that scholars were actually compelled to read all those books; for, to prolong the chain of science, one logically had first to go through the whole length of it. So that scholastic science could not but soon degenerate into hopeless erudition.

The case would be very nearly the same for a system of knowledge based on the second kind of elements, which we have discriminated in science; namely, *facts*.

In the age of Descartes, to be sure, no attempt to build a science on facts only had ever actually been made. Experimental work was still in its infancy. However, a man like Descartes, who was fully aware of the value of such work, could not but perceive the danger which a science based on experiments would have to face. The danger was to pile up facts without the guidance of reason. Such a task would be entirely indeterminate just as is the piling up of logical propositions. It would be endless, and a man might consume his life in this task without becoming any wiser.

Notwithstanding this danger, the kind of science to which I am now alluding is still favored, in our own time, by a few scientific circles.

Arguing that theory is always open to doubt, while a fact in itself, is something solid, there are men who believe that the scientist's activity should all be concentrated upon this one aim: *to acquire new facts.* The men who are promoting such views do not always realize that *their* science—although very different as to the materials from the old scholastic science—will be exactly the same in spirit; or rather it will be the same in the lack of spirit. Accumulation of particular truths, but no leading principle, no illuminating light. Erudition exalted. Discrimination and intelligence secondary. A cumbrous, aimless, hopeless and dead science.

It is against such an ideal, such a conception of science that René Descartes took his stand.

Descartes was endowed with a revolutionary turn of mind. He had, as far as science is concerned, no respect whatever for tradition. Even Greek geometry, which we consider so perfect, is condemned by him. He mentions that all scientific productions of former generations are entirely worthless.

All that we know of Descartes, indeed, is in sharp contrast with the figure of the old schoolman.

First of all, Descartes is *not* a professor.

In the Middle Ages and later, most of the students of science were engaged in the teaching profession. Secluded from the world of action, they were anxious not to let any outsider intrude into their field of knowledge. They jealously closed the doors of science in the face of all Philistines.

Not so with Descartes. How could a man with his temperament be contented with university routine? From his youth, Descartes had felt inclined to live an active, independent and dangerous life. He travelled all over Europe, he was a soldier and fought in Holland and Germany. Later he moved from one place to another, not being able to settle anywhere until he met with a premature death in Sweden.

These facts we have to bear in mind if we want to understand, not Descartes only, but all the great French scientists of the same time. Fermat, who is considered by many as the most prominent mathematician of that age, was not a university man either, but a judge at Toulouse. Desargues, famous among geometers, was an enginer. Pascal was a private gentleman, self-taught.

The lives of all these learned men were widely different. And yet they all had something in common and belonged to the same class. They represented the type which the French of the seventeenth century called an *honnête homme.* To all of them the scholar of the scholastic type is equally abhorrent. He is the man who has been so fitly

ridiculed by Molière, in the *Thomas Diafoirus* of the "Malade imaginaire." Diafoirus is a reputed magister, who has much dialectic ability, but no judgment. The *honnête homme* does not boast of any special acquirements or training, but is richly endowed with good, simple, common sense.

On that notion of "good sense" (*bon sens*) is based the whole Cartesian theory of science. According to Descartes, *bon sens* is a common property, a common gift of which all men have their share. It is the power which men have to act and think not only in agreement with their bodily experience and with the laws of logic, but in agreement with reason.

From this view an obvious inference follows Science shall not be the exclusive property of specialists any more. But it will be open to laymen; and the layman will even do better than the specialist because he will not indulge in formal erudition and bluff, but his aim will be to make science clear, simple, well ordered, intelligible to any sensible human being, and to make it a living, instead of a dead thing.

The chief characteristics of such a science may be summed up as follows:

First of all, as we just said, science will be *simple*. A scientific system which would lack simplicity would be wrong.

This, I admit, will be considered by many as a bold and rather imprudent statement. We certainly agree with Descartes when he condemns those conceited scholars who are prone to make science complicated just for the sake of appearing as great men in the eyes of ignorant people. But why, indeed, should we believe, and believe on principle, that a science explaining the laws of mechanics, physics and other natural phenomena, is bound to be simple or can be simple?

To confirm such an opinion, Descartes feels compelled to build an elaborate metaphysical system which, according to philosophy, is now a thing of the past. As a scientist, however, we may think that Descartes was right; for the conception of science, which, after many trials, mankind has finally reached, seems to vindicate his statement. Not that science will be just as simple as Descartes thought. But we have come to regard science largely as an arbitrary construction which justifies its course and its hypotheses chiefly by being convenient and simple.

The second characteristic of Cartesian science is that it will *not* be, in any respect, a collection of data or propositions. As we don't know beforehand what data, what deductions, what theorems will be needed for future scientific or practical purposes, therefore, Descartes would say, it is quite useless to gather and hoard such commodities in advance. What we need is a *method* which will give us the power to get the data and to get the propositions as soon as we require them.

A third fundamental characteristic of science—which is not explicitly defined by Descartes himself, but follows from his conceptions—relates to the sort of work which the scientist of high rank has to accomplish, and to the special abilites that are required of him.

Since the task of the scientist does *not* consist in piling up data and reasonings, but in presenting a few clear, comprehensive and far-reaching notions, it follows that this task will be chiefly one of choice and discrimination. Not all the things that are true are useful and worth saying, but only a few, which the intelligent man has to pick out and to discriminate

How will such a discrimination be carried out? There is no ready answer to this. The question is one for intuition, for intelligence and foresight to decide. To choose the fundamental notions or *hypotheses* on which a scientific construction will be based, to select a *plan* for this construction, to find out the *tests* which will help to compare the construction with experiments, all this forms the most delicate part of the scientist's task. And the most important part too. Between the man who is only capable of deducing and combining ideas or data and the man capable of making the right choice, there is the difference which divides scientific ability from genius.

Let us finally mention a fourth characteristic of Cartesian science, which concerns its form, not its contents. It is quite obvious that, *if* a scientific system is to be simple, comprehensive, and built up with discrimination, the presentation of this system will have to offer corresponding qualities. It must be brief; it must be well ordered; it must be expressed in precise, well chosen words; above all it will be *clear*.

Boileau said, "ce que l'on conçoit bien s'enonce clairement." The reverse is also true. If an idea can not be clearly worded, there is ground to fear that it is badly conceived. The fact that a scientific statement is expressed clearly is the test showing that the statement is sound in regard tc reason and is properly discriminated.

A fine example, in this respect, is set by Descartes himself in his "Geometrie," a treatise which, just in a few pages, lays the foundations of analytical geometry. Another beautiful example is found in Pascal's dissertations on hydrodynamics, which have often been described as being as many little gems. But I can not enter here into a survey of the *results* to which the Cartesian principles have led. My object was simply to show how these principles have been introduced into science and what they do mean.

They were, as we have seen, the natural outcome of the views held by the best French scientists of a time in which modern thought generally, and French thought particularly, began to develop on new and most promising lines. Descartes had a clear conception of the

type of science which was wanted in his age. However, the promise then given of a sound rational science, as opposed to a purely logical or merely empirical science, was not actually made good until a much more recent date. If we except pure mathematics, or rather some parts of pure mathematics, the system of science on which we rely today was not actually framed, in its present shape, before the end of the eighteenth century. Then it was that the older sciences, like analysis, physics, chemistry, were placed upon really strong foundations, while biology and all the new sciences were just emerging from the chaotic state. The nineteenth century has justly been described as the century of science. It is therefore of special interest for the student of French civilization to see how France has played her part during that most remarkable period.

* * *

It was shortly before 1800 that, after a period of comparative stagnation, a new revival of scientific thought became apparent in France. Curiously enough this revival took place at a time which does not seem at all favorable—in the midst of the French revolution and the Napoleonic campaign. This is a strange coincidence. But we must remember that the French scientist of Descartes' class is not bound to be an indoor scholar or a white-bearded doctor. For him, there is no contradiction between learning and life. Rather would he believe that active life is an inducement to scientific work, that the great expenditure of energy which comes from danger is likely to give an impetus to science itself. So did it happen that the period about the year 1800 was one of great scientific production, and the very men to whom we owe that production have played a personal part in the great drama which was then shaking France and all Europe.

A few names will be sufficient, I think, to prove the correctness of this association.

Lazare Carnot, born in 1753, was one of the promoters of modern geometry. But, at the same time, he was an army officer and a statesman. He proved a most efficient minister of war. He was one of the first to discover Napoleon's ability and himself deserved the title of "organisateur de le victoire."

Another member of the Carnot family, Sadi Carnot, one of the founders of thermodynamics, was also an army officer engaged in active service.

Gaspard Monge was a great inventor in geometry. But he took an active part in the Revolution, was a state minister and a member of Napoleon's expedition to Egypt. Other members of the same expedition were Geoffroy-Saint-Hilaire, a well known biologist, and Berthollet, famous in chemistry.

Fourier, a promoter of mathematical physics, lived a most threat-

ened life throughout the Revolution. Lavoisier, who is considered by many as the chief founder of modern chemistry, held various posts in the Revolutionary administration, and was finally sentenced by a Revolutionary court and put to death.

Poncelet, a most original geometer, was an officer in Napoleon's army and made his greatest discoveries when a prisoner in Russia.

Arago, a great astronomer born in 1786, was also a strenuous man of action. Just when the war was raging between England and France, he was engaged in the measurement of a geodesic arc in Spain and North Africa. He was taken prisoner a number of times but always managed to escape under the most perilous circumstances.

Such were the French scholars of the beginning of the last century.

But quieter times have come, and the scientist of the Carnot type is now a figure of the past. Occasionally, to be sure, the tradition of 1800 has been renewed. Not to speak of a recent prime minister, there are a number of scientists who have played an active part in French public affairs. Conspicuous among them was Berthelot, one of the founders of organic chemistry, who not only was a senator and statesman, but took personal interest in nearly all fields of knowledge and action.

Berthelot's case is however an exception. Scientific work nowadays, when of the original and creative kind, requires so much time, so much application and concentration, that it can not be easily associated with outside activities. The reverse, however, is not true. It is quite feasible and most useful for a man engaged in active life to be thoroughly trained in science. In this respect, at least, France has preserved the tradition of 120 years ago. To promote scientific thought among men of action, the great inventors of that time had opened a new school, the *Ecole Polytechnique*. Up to the present day, this school has played an important part in the life of the country; through this institution and others, the best French engineers, officers, administrators, are given a scientific training of high standard and many of them thus develop a turn of mind in which we easily recognize the Cartesian spirit: clearness, preciseness, a rigorous method. The scientific ability, the directness of mind of the French artillery officers has often been praised during the war. It is largely due to the training and tradition of the *Ecole Polytechnique*.

But let us turn to the genuine research work done in France and see what remarks may be offered about it.

Coming to this point, I confess that I feel somewhat puzzled. The pure scientist of modern times is not in the least a striking figure. He is a simple man, living a simple life in his study or his laboratory. Many would even suspect him of being some kind of fossil with no passion, no feeling, no human weakness. Of course, this suspicion is

not correct. A man who does creative work is bound to have passions, but not of the sort that break out in every day life. Let us try, however, to discover, under the monotonous surface of his existence some characteristic features of the man.

I have already mentioned the fact that the French tradition, as defined by Descartes, is strongly opposed to the spirit of the old schools of specialists. The modern French student, to be sure, is mostly obliged to specialize. This has become necessary if one wants to do useful work. But the French student rather regrets this restriction on his activity, and he has none of the specialist's tastes or manners.

A natural consequence of the specializing habit is the way in which followers of the same line (the same *Fach*, as the Germans would say) are wont to associate together and live a distinct life. In so doing modern specialists are quite in keeping with the old custom. The old universities were precisely such associations of learned men who conversed and discussed among themselves without any regard for the opinions of the lay people outside. Their one aim was to gain authority and influence over their own kind. And the ambition of every young scholar in former times was to become a professor, a magistrate in his turn, and to be surrounded by a crowd of docile followers.

The scheme is not altogether a bad one. Anyone, I think, who has studied in one of the older German universities must admit that *there*, at least, some of the traditions of the past have been preserved with great advantages to all concerned. In the quiet city of Göttingen, among the woods and hills of the Hanover province, famous professors, a few years ago, still lived the same learned, methodic life which their predecessors had led. They worked in close association with their students. They ate and drank with them. They guided them step by step. And they used to share with them their intimate thoughts, their hopes, the difficulties which they met in their own researches; thus occasionally getting valuable assistance from the same young men whom they helped to get a start in academic life. The deep humility of many a student in such surroundings, his complete submission to his master, were rather surprising to the foreigner; but it can not be denied that the cooperation which such a submission made possible was followed in many cases by remarkable results.

In France, however, the ways of scientists and the conditions of university life are of a different type.

Like Descartes, the French student of science is mostly a man with an independent turn of mind. There lies his strength as well as his weakness. Working alone, and avoiding too frequent contact with his fellow-workers, he may thus have a better chance to discover really new and unexplored ways. He is less exposed to the danger of having his vision obscured by tradition, by opinions or prejudices of other

men, by the natural inclination to imitate. But, on the other hand, there are some kinds of work in which a single-handed man, whatever be his own resources, is not likely to succeed, in which some sort of cooperation is highly desirable. This is specially true of laboratory work, where a long series of delicate experiments is required. In this respect many Frenchmen will frankly admit that they have often been somewhat deficient. In organized scientific work, in teamwork, France is not as successful as she might have been. However, it should not be forgotten that, so far, the most original, the deepest discoveries have not been obtained by teamwork. And it is not unusual that one single man, in a small, inconvenient laboratory, lacking all modern conveniences, will make a striking discovery. Such was the case of Pasteur forty years ago. Such has been the case of the Curies.

To the individualistic turn of mind of the French man of science is probably due the fact that the intercourse between teachers and pupils is not in French universities what it is in a place like Göttingen.

We have seen that Fermat, Descartes and Pascal were not university men. Even at the present day, the French scientist, although he usually teaches in some university, is not exactly the man whom most people would call a professor. He does not associate with his students as closely as the typical teacher does. Henri Poincaré, for instance, was often described as being peculiarly closed and inscrutable to the many who came to study under him. He utterly disliked to speak about his own work while it was going on. He believed that absolute concentration was necessary to bring forth original thought and that academic intercourse, during the period of invention, could not but spoil the process. This view, it will be noticed, is in perfect agreement with the Cartesian principles. According to the French notion science is by no means the result of addition, of accumulation of knowledge and research. It is an accomplishment of reason, an act of direct intuition, which can not be divided and can not be made easier by combining the brains of several people.

It would be, however, quite a mistake to believe that French professors don't care to have frequent and friendly intercourse with their students. Henri Poincaré was much interested in beginners. But he did not try to impress his ideas upon them. He was rather anxious to get out of them the ideas which they might be forming in secret.

French students, like those of some other countries, are rather fond of criticizing. They have not too much respect for their teachers and sometimes follow their leadership chiefly by taking opposed views. Now you will find that the French professor, as a rule, does not try to check that tendency. He knows that there is an exaggeration in it, which will wear out with youth; but he thinks, as Descartes did, that a young, vigorous, not too scholarly mind, even if it has not yet hoarded

a big amount of knowledge, is apt to fall upon new and original ideas which a more experienced man might overlook. He believes in the power of fresh minds, not hampered by erudition, and he does his best to stimulate such minds.

The conditions which I have described so far as prevailing in modern France relate chiefly to creative work and invention. Invention, however, is only one part, the most important one, of scientific activity. Another part is the presentation and explanation of the facts and ideas, the making of a system or theory.

What shall we call, in science, a *theory?* This point we touched already when we were discussing Cartesian science. But it is only in recent years that the meaning and purport of constructive theories have been distinctly recognized; and French scientists and philosophers have helped much to clarify the question.

The French idea is—let us repeat it once more—that it is less important to collect data than to make a pertinent choice between them and to order and handle them according to clear principles, well reasoned out. From this it follows that the French scientist is bound to pay special attention to the requirements and to the merits of theories.

In what respect may we say that a scientific theory is contingent? To what extent is the theory a thing of our own making, the result of our own discrimination? To what extent, on the other hand, is it imposed upon us from the outside by an external necessity? Such were the problems which several French thinkers have discussed at length from the point of view of modern science.

The conclusion reached was quite in keeping with Descartes' view, namely, that the best science is the one which is most convenient and simple. Many different systems of science would be equally correct (for instance non-Euclidean geometry is just as true as Euclidean geometry). But only the science which is simple will be commendable.

It is not for me to discuss these views from the standpoint of philosophy. The metaphysical questions which they call forth may be debatable. But the scientific conclusions and precepts which men like Henri Poincaré cultivate have often been described as a scientific form of pragmatism. This is partly, but only partly true. To describe that position correctly we have to bear in mind that the Cartesian conceptions are still dominant in France. We are trying to mould science so as to make it simple. Now what does the word "simple" mean here? Is it exactly the same thing as *convenient?* Descartes' answer to this question is based on principles which don't satisfy us today. Yet his leading idea has survived; namely, that simplicity in science does not mean primarily practical convenience, but rather means being simple in regard to *reason*, in regard to Cartesian *good sense*. The constant

aim and preoccupation of the French scientist, when he makes up a theory, will be to take reason for his guide.

But if we put the matter so, one may ask, how then shall we define that faculty of reason on which we cause all science to rest? This question the modern scientist will not answer. It is beyond him. He is not as bold as Descartes and does not venture to describe reason. But he firmly believes that he knows quite distinctly, quite definitely, what a theory is to be like if it is built in accordance with the precepts of that undefined faculty of reason.

Take, for instance, the modern theories of physics as they grow in the hands of such great scientists as Hertz, Maxwell, Oliver Lodge, and see what becomes of the same theories when they are accommodated to French taste by Henri Poincaré, Duhem, Langevin or Perrin. You will recognize at once that the said theories are distinctly modified when they cross the borders of the different countries—which shows that there is really such a thing as a national ideal in scientific construction.

A striking feature in the books of many great English scientists of recent date is the constant appeal which they choose to make to material illustration, to concrete images and comparisons. Open an English treatise of electricity, Pierre Duhem used to say. You will be surprised to find there constant talking about strings, ropes, wheels, pulleys, waterfalls and so on. It seems, indeed, that such comparisons and interpretation are a distinct help to the English mind. It would not be quite so with the French mind. The French would think that this repeated resorting to imagination is rather likely to obscure the deep meaning of the theory.

Let us take, now, some German treatise of the first rank on the same subject. There we find a predilection for abstract, logical, well deduced constructions and mathematical reckoning. No material illustration of the facts, no attempt, even, to justify the long work except when it comes to be concluded. The peruser of the treatise is expected to be a disciplined, docile sort of man who will take the trouble of going through the whole, of devoting himself to hard reading without knowing beforehand where he is taken to and why he is asked to go that way. Science, so conducted, is chiefly a formal system. It may finally lead to practical applications, but, all along the way, you don't know whether it will; and the useful construction does not differ in form and character from any other which would be useless.

The French point of view in such matters is somewhat different. It is neither the English nor the German standpoint just described. The leading feature, in the presentation of a theory of physics in France is neither concrete interpretation nor pure deduction and computation.

Few images, to avoid dispersion of the mind, and a logical apparatus as reduced as possible, to avoid obscuration of the ideas by the

formal elements of deduction. The ideas themselves as clear, as obvious, as approachable to common sense as they can be. Such will be for the French the ideal theory.

* * *

I have tried to define, in the preceding pages, the features which seem to be most apparent in the personality, the work and the achievements of French men of science. To close this article, I confess that I have no definite conclusion to offer; nor would it be safe to synthetise any more an account which is already too schematic. In fact, real conditions can not possibly be as simple as one might infer from this account. The tendencies which I have tried to point out are often more potential than actual and only half—if at all—conscious. The exceptions, also, are numerous, so that any synthetic picture, like the one I have had in view, can never be more than partly true. But should the picture, for this reason, be dismissed as illusory and devoid of any practical value? I don't think so. When there is so much talk about exchanging professors, students, ideas, between distant nations, I believe that it may be worthwhile to emphasize, even with some exaggeration, the traits that are most likely to affect a would-be visitor to a country. This may help to avoid misunderstandings. If science of the type which I have described is to your liking, then go to France and you will probably come across some good representatives of such a science. If it disagrees with you, then stay at home and be indulgent.

ORIGIN OF THE ELECTRICAL FLUID THEORIES

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IN a previous paper an attempt was made to show how the hypothesis of an electric effluvium or an electric atmosphere, by means of which electrified bodies were supposed to exert an attraction or repulsion upon each other, played a prominent part in electrical theory for more than 150 years. In the meantime two kinds of electrification had been discovered, and this discovery greatly increased the difficulty of finding a satisfactory explanation of the phenomena of attraction and repulsion.

The discovery of electric induction by Stephen Gray was referred to in the previous paper. This discovery, along with many other important electrical discoveries, was made in 1729. In 1733, du Fay, a French officer and engineer, who had been repeating Gray's experiments, communicated to the Royal Society through the Duke of Richmond the first announcement of the discovery of two kinds of electrification, or, as he believed, two kinds of electricity. This letter was read before the Royal Society and is published in volume 38 of the Philosophical Transactions. In it du Fay describes a number of new electrical discoveries which he had made, some of them very important, as, for example, the fact that all solids when suitably insulated may be electrified by friction or contact with other bodies. Then he says:

> Chance has thrown in my way another Principle, more universal and remarkable than the preceding one, and which casts a new Light on the Subject of Electricity. This Principle is, that there are two distinct Electricities, very different from one another; one of which I call *vitreous Electricity*, and the other *resinous Electricity*. The first is that of Glass, Rock-Crystal, Precious Stones, Hair of Animals, Wool and many other Bodies; The second is that of Amber, Copal, Gum-Lack, Silk, Thread, Paper, and a vast Number of other Substances. The Characteristick of these two Electricities is, that a Body of *vitreous Electricity*, for Example, repels all such as are of the same Electricity; and on the contrary attracts all those of the *resinous Electricity*; so that the Tube made electrical, will repel Glass, Crystal, Hair of Animals, &c. when rendered electrick and will attract Silk, Thread, Paper, &c. though rendered electrical likewise. Amber, on the contrary will attract electrick Glass, and other Substances of the same Class and will repel Gum-Lac, Copal, Silk Thread, &c.
>
> Two Silk Ribbons when rendered electrical will repel each other; Two Woollen Threads will do the like, but a Woollen Thread and a Silk Thread will mutually attract one another.

Du Fay justly regarded this newly discovered fact regarding electrification as capable of explaining many electrical phenomena which up to that time had been incapable of explanation. He does not propose any hypothesis as to the mechanism of attraction or repulsion, nor does he propose any theory as to the coexistence of the two kinds of electricity in the same body or have anything to say about their neutralizing each other when combined in suitable proportions. This part of the two-fluid theory seems to have been proposed by Robert Symmer about 25 years later.

In 1745 a great impetus was given to the study of electrical phenomena by the discovery of the shock which may be produced by the discharge of an electrical condenser through the body. This discovery was first made by Dean von Kleist of the Cathedral of Camin in Pomerania. Dean von Kleist found that he apparently could lead a larger quantity of electricity down a nail into a flask containing mercury or alcohol when he held the flask in his hand than when it stood on a table. In trying to remove the nail from the flask after he had, as he supposed, filled it with electricity, he received a shock. He described this experiment and his sensations on receiving the shock in letters to several scientists in Berlin, Halle and elsewhere. These men failed to verify the experiment, perhaps on account of the poor insulating quality of the glass used, and none of them seemed to attach much importance to the announcement of Father von Kleist.

Within three months a similar discovery was accidentally made in the laboratory of Peter van Musschenbroeck in Leyden. Van Musschenbroeck was one of the leading scientific men of his day and his discoveries were widely published. He communicated his discovery in a letter to Réaumur, in Paris, and it was published in the Mémoires of the Académie in 1746.

The letter to Réaumur was written in January, 1746, and the account of the discovery which it contained is given below as translated in Benjamin's "Intellectual Rise of Electricity."

> I wish to inform you of a new but terrible experiment, which I advise you on no account personally to attempt. I am engaged in a research to determine the strength of Electricity. With this object I had suspended by two blue silk threads, a gun barrel, which received electricity by communication from a glass globe which was turned rapidly on its axis by one operator, while another pressed his hand against it. From the opposite end of the gun barrel hung a brass wire, the end of which entered a glass jar, which was partly full of water. This jar I held in my right hand, while with my left I attempted to draw sparks from the gun barrel. Suddenly I received in my right hand a shock of such violence that my whole body was shaken as by a lightning stroke. The vessel, though of glass, was not broken, nor was the hand displaced by the commotion; but the arm and body were affected in a manner more terrible than I can express. In a word, I believed that I was done for.

This "new and terrible experiment" of van Musschenbroeck's was widely published, and was repeated by scientific men all over Europe, in many cases before large audiences. It is doubtful if any scientific experiment ever created a more profound interest with the public to whom it was demonstrated than did the shock from van Musschenbroeck's electrified vial, and nothing ever seemed a greater mystery than it did until Franklin proposed the explanation which is still accepted. The apparatus by which the shock was produced came to be called generally the Leyden phial or Leyden jar; but in Germany, out of consideration for Dean von Kleist's discovery, it is called the *Kleistschen Flasche.*

Soon after the announcement of van Musschenbroeck's discovery, Benjamin Franklin, of Philadelphia, was presented with a tube of flint glass and was told of some of the wonders of electricity and the properties of the mysterious flask by his friend, Peter Collinson; and he at once began the series of electrical experiments, the results of which have profoundly modified all electrical theories from that time until the present, and which seem destined to determine to a large degree the electrical theories of the future.

Franklin's original discoveries were not more numerous than those of Stephen Gray, though he discovered the effect of points in collecting or discharging electricity, proved the identity of atmospheric and frictional electricity, discovered that bodies within a charged hollow conductor will take no charge from the inner surface of the charged conductor and explained the phenomena of the mysterious flask of von Kleist and van Musschenbroeck; but Franklin proposed a physical interpretation of the phenomena of electricity which received almost universal acceptance at the time, and which now, since several other theories have been tried and have proved unsatisfactory, seems destined again to become the fundamental theory.

It may be interesting to know that the theory of a single electric fluid as the cause of both kinds of electrification discovered by du Fay was proposed almost simultaneously by Franklin in Philadelphia and by William Watson in London, and from virtually the same experiment. Franklin announced his theory in a letter to Peter Collinson, dated June 1, 1747. After speaking of two men insulated on cakes of wax and electrifying themselves, one from rubbing a glass tube and the other from holding his knuckles near to the rubbed tube, while a third man stands on the floor near them, he says:

> These appearances we attempt to account for thus: We suppose, as aforesaid, that electrical fire is a common element, of which every one of the three persons above mention has his equal share before any operation is begun with the tube. A, who stands on wax and rubs the tube, collects the electrical fire from himself into the glass; and his communication with the common stock being cut off by the wax, his body is not again immediately

supplied. B, (who stands on wax likewise) passing his knuckle along near the tube, receives the fire which was collected by the glass from A; and his communication with the common stock being likewise cut off, he retains the additional quantity received. To C, standing on the floor, both appear to be electrified: for he having only the middle quantity of electrical fire, receives a spark upon approaching B, who has an over quantity; but gives one to A, who has an under quantity. If A and B approach to touch each other, the spark is stronger, because the difference between them is greater: after such touch there is no spark between either of them and C, because the electrical fire in all is reduced to the original quantity.

It may not be without interest to compare this concise explanation with the much more labored one proposed by Watson for the same phenomenon. Watson refers to an observation that had been made that a man standing on wax and holding his hand on a rotating glass globe could take no appreciable charge so long as the globe was insulated and held at a distance from other conductors, but would become charged if a conductor or another person, either insulated or uninsulated, should draw off the charge from the glass.

Watson's discussion of this experiment is given in Volume 45 of the *Philosophical Transactions of the Royal Society*, and is, in part as follows:

1. That what we call Electricity is the Effect of a very subtil and elastic Fluid, diffused throughout all Bodies in Contact with the terraqueous Globe (those Substances hitherto termed Electrics *per se* probably excepted), and everywhere, in its natural State of the same Degree of Density.

2. That this Fluid manifests itself only, when Bodies capable of receiving more thereof than their natural Quantity are properly disposed for that Purpose; and that then, by certain known Operations, its Effects shew themselves by attracting and repelling light Substances, by a snapping Noise, Sparks of Fire &c. directed towards other Bodies, having only their natural Quantity, or, at least, a Quantity less than those Bodies from which the Snappings, &c. proceed.

3. That no Snapping is observed in bringing any two Bodies near each other, in which the Electricity is of the same Density, but only in those Bodies in which the Density of the Fluid is unequal.

4. That this snapping is greater or less, in proportion to the different Densities of the Electricity in Bodies brought near each other, and by which Snapping each of them becomes of the same Standard.

5. That Glass, and other Bodies which we call Electrics *per se*, have the Property of taking this Fluid from one Body, and conveying it to another, and that in a Quantity sufficient to be obvious to all our Senses.

6. That in the Experiment in question, the Reason why no Snapping is observed by a Person upon the Floor touching him who rubs the Globe with his hands standing on Wax, without at the same time some other Non-electric supported by Originally Electrics, or otherwise being in contact with the Globe, is owing to whatever Part of this Man's natural Quantity of Electricity, taken from himself by the Globe in Motion, being restored to him again by the Globe in its Revolutions; there not being any other Non-electric near enough to communicate the Electricity to; and therefore, in this Situation, the Electricity of the Man suffers no diminution of its Density.

7. That the fact is otherwise, when everything else being as before, either a Gun-barrel suspended in Silk Lines, or a Man supported by Wax, or such like, is placed near the Globe in Motion; because then, whatever part of the Electricity of the Person rubbing is taken from him, is communicated either to the other Man or the Gun-barrel, these, from their Situation, being the first Non-electrics, to which Electricity taken from the Person can be communicated.

8. That under these Circumstances, as much Electricity as is taken from the Person rubbing is given to the other; by which means the Electricity of the first Man is more rare than it naturally was, and that of the last Man more dense.

9. That the Electricity in either of these Persons is in a very different State of Density from what it naturally was, or from that of any Person standing upon the Earth; this last being in a middle State between the two other Persons; that is, he has not his Electricity so rare as the Man rubbing the Globe, nor so dense as that of him supported by Electrics *per se*, and touching the Equator of the Globe.

10. That therefore the same Effect, a Snapping, is observed upon bringing any Non-electric near either of these Persons, from very different Causes: For it is apprehended, that, by bringing the Non-electric near him, whose Electricity is more rare, this Snapping restores to him what he had lost; and that by bringing it near him, whose Electricity is more dense, it takes of his Surcharge, by which means their original Quantity is restored to each.

Watson then refers to the explanation of the same phenomenon by Franklin, with which he had been made acquainted after the presentation of his paper to the Royal Society. Thus he says:

At this time I am tne more particular concerning the Solution of this singular Appearance as Mr. *Collinson*, a worthy member of this Society, has received a Paper concerning Electricity from an ingenious Gentleman, Mr. *Franklin*, a Friend of his in *Pennsylvania*. This Paper, dated June 1, 1747, I very lately perused, by Favour of our most worthy *President*. Among other curious Remarks, there is a like Solution of this Fact; for though this Gentleman's Experiment was made with a Tube instead of a Globe, the Difference is in no-ways material. As this Experiment was made, and the Solution thereof given upon the other Side of the *Atlantic Ocean* before this gentleman could possibly be acquainted with our having observed the same Fact here, and as he seems very conversant in this part of Natural Philosophy, I take the Liberty of laying before you his own Words.

Then follows Franklin's explanation of the experiment as we have already quoted it.

Franklin's theory of the relation of electricity to material bodies is more fully given in a letter to Peter Collinson under date of July 29, 1750, the year of the publication of Watson's paper. He says:

1) The electrical matter consists of particles extremely subtile, since it can permeate common matter, even the densest metals, with such ease and freedom as not to receive any perceptible resistance.

2) If any one should doubt whether the electrical matter passes through the substance of bodies, or only over or along their surfaces, a shock from an electrified large glass jar, taken through his own body, will probably convince him.

3) Electrical matter differs from common matter in this, that the parts of the latter mutually attract, those of the former mutually repel each other. Hence the appearing divergency in a stream of electrified effluvia.

4) But though the particles of electrical matter do repel each other, they are strongly attracted by all other matter.

Franklin introduced the use of the algebraic signs + and — to indicate the electrical conditions which Watson referred to as denser or rarer electrical states. Thus a body which contained a greater amount of the electrical fluid than it would contain if in electrical contact with the earth was said by Franklin to have a + charge, and one which contained less of the fluid than it would naturally take from the earth was said to have a — charge. From this point of view, the body with a + charge would give electricity to the earth and a body with a — charge would take electricity from the earth if put into electrical contact with it.

Cavendish used the term "pressure" to indicate the same idea. He regarded the electrical fluid in all bodies as under an external pressure and as always flowing in the direction of least pressure. A body with a + charge would then be one in which the electrical fluid was under greater pressure than in the earth, and a body with a — charge as one whose electrical fluid was under a less pressure than the earth's electrical fluid. If the electrical fluid is regarded as compressible, as it must have been by Watson, the + condition would indicate both an increased pressure and an increased density.

All of these concepts assumed an electrified earth, and, as was shown in the previous paper, it was upon the assumption of an electrified earth that Cavendish, and probably Aepinus, undertook to prove the absence of an electrical atmosphere about charged bodies.

The concept of an electrically neutral earth seems to be due to Robert Symmer, in England. In 1759, during Franklin's residence in England, Symmer borrowed some electrical apparatus from him and repeated some of his experiments. As a result of these experiments, he came to a different opinion as to the nature of electrification from the one proposed by Franklin but failed to convert Franklin to his point of view.

In Volume 51 of the *Philosophical Transactions* is a group of four papers by Symmer in which he gives his reasons for believing in two electrical fluids. Of the two principal arguments which he proposes, one is derived from the sensation experienced when the two coatings of a weakly charged Leyden jar are touched by the fingers of one hand. In this case, Symmer says the sensation is that of a shock, or blow, upon the fingers touching both coatings of the jar, with no distinction to indicate that the electricity strikes from one coating rather than from the other.

The other argument is based upon the fuzzy appearance on both sides of a card or of several sheets of paper of the perforation made by a single electric spark, "indicating that the electric fluid has either entered or left both sides," and upon the effect of a spark discharge through a number of sheets of paper with a sheet of tin-foil between them. In this case the tin-foil may not be perforated and the holes made by the spark on opposite sides of the tin-foil may not meet opposite the same point in the foil. In this case there is a little dent in the tin-foil opposite both perforations, indicating that the tin-foil has been struck from opposite sides in the two cases.

After referring to the apparent difficulty of explaining these phenomena by a single electric fluid, Symmer sums up his case as follows:

> On the other hand, it is my opinion that there are two electrical fluids (or emanations of two distinct electrical powers) essentially different from each other; that electricity does not consist in the efflux and afflux of those fluids, but in the accumulation of the one or the other in the body electrified; or, in other words, it consists in the possession of a larger portion of the one or of the other power, than is requisite to maintain an even balance within the body; and, lastly, that according as the one or the other power prevails, the body is electrified in one or in another manner.

It will be seen that Symmer has added to du Fay's notion of two electricities the assumption that all bodies in their natural state possess both kinds but in such quantities that their individual effects are neutralized.

It is interesting to know that Franklin was ignorant of du Fay's discovery when he proposed his theory of a single electric fluid. Later, his friend, Mr. Kinnersly, of Boston, who had taken part in some of Franklin's work, made the discovery that the electricity induced by the friction of the hand on a sulphur globe would discharge the electricity induced in the same way on a glass globe. Thus, if he charged a Leyden jar by sparks from a rubbed glass globe and then allowed a rubbed sulphur globe to spark into it, he found that the jar was first discharged and then, if the sparking were kept up, became charged again. He also found that the jar remained discharged if the glass globe and the sulphur globe were allowed to spark into it at the same time. This caused him to inquire of Franklin whether the glass, or the sulphur, acquired a + charge when rubbed.

Franklin concluded for several reasons, the most important of which seems to have been the different character of the brush discharge of the two, that glass took the excess charge from the body rubbing it, while sulphur gave off electricity to the rubber. Thus, the brush discharge from a positively electrified body is longer and more diverging than from a negatively electrified body. Franklin also observed that the "electric wind" given off from a point is stronger from a body electrified from glass than one electrified from sulphur. He concluded for

these reasons that the electric fluid was escaping from the charged glass and was being collected by the charged sulphur.

Franklin did not attach much importance to his attempted identification of the + and — electric conditions. Priestley says that one question which greatly puzzled Franklin was why negatively electrified bodies should repel each other, since his theory was that particles of electric fluid repel each other while the particles of material bodies attract each other. It would seem from these hypotheses that two bodies containing a deficiency of the electric fluid should attract each other.

The opinion that the electric fluid is attracted by the particles of material bodies led to the modification of Franklin's theory by the introduction of the assumption that the particles of material bodies, when free from electricity, must also repel each other. In making this assumption, an important discovery made by Stephen Gray was seemingly overlooked, and though this observation has been repeated thousands of times it seems still to be overlooked by most writers on electrical theory. Gray found that a hollow box of wood when charged seemed to take as great a charge as a solid block of the same size, and every student of electricity now knows that a hollow conductor, no matter how thin its walls, has the same electric capacity as a solid conductor of the same shape and size. If the particles of the electric fluid were attracted by the particles of the conductor, this would not be the case.

The Franklinian theory, even when modified by the assumption of a repulsion between the atoms of material bodies still differed in important respects from the two fluid theory of du Fay and Symmer, since in the latter theory in its final form an electric discharge always consisted in the passage of both kinds of electricity in opposite directions between the two conductors. This theory as it was developed prior to 1767 is described by Priestley, in his "History of Electricity," as follows:

> To show my absolute impartiality, I shall, notwithstanding the preference I have given to Dr. Franklin's theory, endeavor to represent this to as much advantage as possible, and to do it more justice than has yet been done to it, even by Mr. Symmer himself; who, as I observed before, has fallen into some mistakes in his application of it. Indeed, hitherto very little pains has been taken with this theory, nor has it been extended to any great variety of phenomena.
>
> Let us suppose then, that there are two electric fluids, which have a strong chymical affinity with each other, at the same time that the particles of each are as strongly repulsive of one another. Let us suppose these two fluids, in some measure, equally attracted by all bodies, and existing in intimate union in their pores, and while they continue this union to exhibit no mark of their existence. Let us suppose that the friction of any electric produces a separation of these two fluids, causing (in the usual method of electrifying) the vitreous electricity of the rubber to be conveyed to the conductor, and the resinous electricity of the conductor to be conveyed to the rubber. The rubber will then have a double share of the resinous electricity, and the conductor a double share of the vitreous; so that, upon this hypothesis, no substance

whatever can have a greater or less quantity of electric fluid at different times; the quality of it only can be changed.

The two electric fluids, being thus separated, will begin to show their respective powers, and their eagerness to rush into reunion with one another. With whichsoever of these fluids a number of bodies are charged, they will repel one another, they will be attracted by all bodies which have a less share of that particular fluid with which they are loaded, but will be much more strongly attracted by bodies which are wholly destitute of it, and loaded with the other. In this case they will rush together with great violence.

Upon this theory, every electric spark consists of both the fluids rushing contrary ways, and making a double current. When, for instance, I present my finger to a conductor loaded with vitreous electricity, I discharge it of part of the vitreous, and return as much of the resinous, which is supplied to my body from the earth. Thus both the bodies are unelectrified, the balance of the two powers being perfectly restored.

When I present the Leyden phial to be charged, and, consequently, connect the coating of one of its sides with the rubber, and that of the other with the conductor, the vitreous electricity of that side which is connected with the conductor is transmitted to that which is connected with the rubber, which returns an equal quantity of its resinous electricity; so that all the vitreous electricity is conveyed to one of the sides and all the resinous to the other. These two fluids, being thus separated, attract one another very strongly through the thin substance of the intervening glass, and rush together with great violence, whenever an opportunity is presented, by means of proper conductors. Sometimes they will force a passage through the substance of the glass itself; and, in the meantime, their mutual attraction is stronger than any force that can be applied to draw away either of the fluids separately.

Thus it is seen that the two fluid theory involves more assumptions than does the theory of a single fluid. In the two fluid theory the notion of combined, or neutralized, electricities seems to be necessary to account for some of the commonest phenomena of electrification. Maxwell speaks of this necessity as follows:

The introduction of the two fluids permits us to consider the negative electrification of A and the positive electrification of B as the effect of *any one* of three different processes which would lead to the same result. We have already supposed it produced by the transfer of P units of positive electricity from A to B, together with the transfer of N units of negative electricity from B to A. But if $P+N$ units of positive electricity had been transferred from A to B, or if $P+N$ units of negative electricity had been transferred from B to A, the resulting "free electricity" on A and B would have been the same as before, but the quantity of "combined electricity" in A would have been less in the second case and greater in the third than it was in the first.

It would appear therefore, according to this theory, that it is possible to alter not only the amount of free electricity in a body, but the amount of combined electricity. But no phenomena have ever been observed in electrified bodies which can be traced to the varying amount of their combined electricities. Hence either the combined electricities have no observable properties or the amount of the combined electricities is incapable of variation. The first of these alternatives presents no difficulty to the mere mathematician, who attributes no properties to the fluids except those of attraction and repulsion, for he conceives the two fluids simply to annul one another, like $+e$ and $-e$, and their combination to be a true mathematical zero. But to those who cannot use the word fluid without thinking of a substance it is difficult to conceive how the combination of the two fluids can have no properties at all, so that the addition of more or less of the combination to a body shall not in any way affect it, either by increasing its mass or its weight, or altering some of its other properties. Hence it has been supposed by some, that in every process of electrification exactly equal quantities of the two fluids are transferred in opposite directions, so that the total quantity of the two fluids in any body taken together remains always the same. By this new

law they 'contrive to save appearances,' forgetting that there would have been no need of the law except to reconcile the "Two Fluids" theory with facts, and to prevent it from predicting non-existent phenomena.

In the one fluid theory as stated by Maxwell the notion of saturation takes the place of neutralization. Thus Maxwell says:

If the quantity of electric fluid in a body is such that a particle of the fluid outside the body is as much repelled by the electric fluid in the body as it is attracted by the matter of the body, the body is said to be saturated. If the quantity of fluid in the body is greater than that required for saturation, the excess is called the Redundant fluid and the body is said to be Overcharged. If it is less, the body is said to be Undercharged, and the quantity of fluid which would be required to saturate it is sometimes called the Deficient fluid.

The Franklinian theory as modified by the addition of the hypothesis that the particles of ordinary matter, as well as the particles of the electric fluid, must be self repellent lasted well into the 19th Century. Its replacement by the two fluid theory seems finally to have been due to its assumption of an electric attraction between the particles of the electric fluid and the particles of material bodies.

Thus Dr. Thomas Thomson, in his *Outline Of The Sciences of Heat And Electricity*, published in 1830 and just before the important work of Faraday, says:

The second datum, that the electric fluid is attracted by matter with a force inversely as the square of the distance, is also inconsistent with the electrical phenomena. For the quantity of electricity accumulated in bodies is always proportional to the extent of their surface, and not to the quantity of matter in them, as would be the case if any attraction or affinity existed between them. All substances, whatever their nature may be, are capable of receiving the same quantity of electricity, provided the extent of their surfaces be equal. And, finally, it has been shown that electricity accumulates only on the surfaces of bodies, and that nothing but the pressure of the ambient atmosphere prevents it from making its escape.

This objection to the single fluid theory seems valid, but it should also apply equally well to the theory of two fluids when an attraction is assumed between either, or both, the fluids and the particles of material bodies. That is, this objection is not more fatal to a theory of a single fluid than to one of two fluids, and cannot be looked upon as deciding between them. This fact seems to have been implicitly recognized by the physicists of that day, since it came to be assumed as a part of the accepted theory of the day that no attraction or affinity exists between either of the electric fluids and material bodies.

But if this be assumed, how may an electrified body attract an unelectrified body? Or how may two oppositely electrified bodies attract each other? This question is asked and answered by Dr. Thomson as follows:

But if there be no affinity or attraction between electricity and matter, it may appear, at first sight, difficult to account for the fact that when bodies are excited, that is, contain a super-abundance of electricity, they *attract* or *repel* each other with forces varying inversely as the square of the distance; bodies having the same kind of electricity repelling, and those having different

kinds attracting each other. But this apparent difficulty admits of a very simple explanation.

If we suppose two excited and insulated spheres placed at a small distance from each other, it is obvious that the only forces which can occasion the motion of the bodies, are the mutual attraction or repulsion of the fluid in the one, to the fluid in the other. For the repulsions exercised by the particles of fluid in each body on one another, can have no effect in producing a motion in the center of gravity of either body. If the two spheres consist of non-conducting matter, the unknown power which gives them the non-conducting property, will prevent the escape of the electricity from each. Therefore the mutual attractions and repulsions of the fluids, as they cannot escape from the matter, may be supposed to carry the matter along with them, and thus to cause the globes to approach or recede, according as they are charged with different kinds of electricity, or with the same kind.

When an excited conducting body is insulated the superinduced electricity forms a coating on its surface, and (if we suppose the body spherical) the thickness of this coating will be everywhere the same. This electricity presses upon the ambient air, which prevents it from making its escape. The excited sphere, in consequence of this action of the electricity, which is proportional to the square of its thickness, will be less pressed upon by the surrounding atmosphere, than if it were not excited. But as the pressure, though diminished, is everywhere equal, there will be no tendency of the sphere to move from its place. Let us suppose the conducting sphere to be charged with positive electricity, and let us conceive a mass of sealing wax or gum lac, charged negatively, to approach it, a portion of the combined electricity natural to the sphere, will be decomposed. The positive portion will accumulate on the surface of the sphere next the mass of sealing wax, being attracted by its negative electricity. The superabundant positive electricity already in the sphere will accumulate at the same surface for the same reason. While the decomposed negative electricity will accumulate at the opposite surface of the sphere, being repelled by the negative electricity of the sealing wax. Thus the coating of electricity next the sealing wax will become thicker than before, while the coating at the greatest distance will become thinner. Hence the electricity in the part of the sphere next the sealing wax will press more upon the air than before, while the air will press more than before upon that surface of the sphere which is farthest from the sealing wax. Both of these pressures have a tendency to cause the sphere to move towards the sealing wax, and if the weight of the sphere be sufficiently small it will move accordingly.

It seems impossible that any one with even a smattering of mechanics could take the above explanation seriously, much less accept it as "a very simple explanation," but Dr. Thomson evidently took it seriously, and he proceeded immediately after the above quotation to put it into mathematical form. And Dr. Thomson was a very eminent scientific man, professor of chemistry in Glasgow, fellow of the Royal Societies of London and Edinburgh and member of most of the learned societies of England and the Continent. It accordingly is probable that this represents the best explanation at that time available of this difficult electrical problem.

De La Rive, in his great treatise on Electricity published twenty-three years later, is still wrestling with this problem. He still seemed satisfied with the explanation which Thomson had given with regard to insulators, that while their particles could have no attraction for electricity, still "The unknown power which gives them the non-conducting property will prevent the escape of electricity from each," and accordingly that they may be pulled together by the attraction of their

electric fluids; but in the meantime Becquerel, Sir W. Snow Harris, and others, had repeated the discovery made one hundred years before by Hauksbee and Stephen Gray that electric attraction and repulsion may take place in the best air pump vacuum. De la Rive, referring to this experiment, says:

> Sir W. Snow Harris has observed that the attractions and repulsions between electrifed bodies take place in vacuo as they do in air; a further proof of the error we should commit by admitting the atmospheric pressure to play a part in the phenomena. This fact, on the other hand, is very well explained by admitting that the electricities are retained, in the portions of the surfaces where they are distributed, by the insulating effect of the film of air that remains adjacent, and in no degree by atmospheric pressure: once retained at the surface by this cause, as they would have been by a coating of varnish, they are no longer able to obey their mutual attraction or repulsion, except by drawing with them the bodies themselves, if their mass is not too great. This explanation, even though it should not be based upon observations made in vacuo, would seem to us in every case preferable to that in which atmospheric pressure is made to intervene; this intervention being implicitly founded on a purely hypothetical idea, namely, that electricity is a fluid of the same kind, and about the same tenuity as air and gases.
>
> Further, while still believing that the electric effects observed in vacuo, as well as others no less curious, of which we shall speak hereafter, are due to the film of air that remains adhering to the surface of bodies, we by no means wish to pretend that conducting bodies have not for themselves the property of preserving, or rather *coercing* on their surface a certain dose of electricity, feeble, it is true, but nevertheless sensible.

At the time of writing of de la Rive's treatise the interest in statical electrical phenomena was declining, owing to Volta's discovery of the electric current at the end of the 18th century and the brilliant discoveries of Davy and Faraday in electrochemistry and of Oersted, Ampère and Faraday in electromagnetic induction. The question as to how two oppositely electrified bodies may attract each other while there is no attraction between the particles of the electric fluid and material particles was overlooked for the time being. Then the electric theory of Faraday was at this time coming to the front in English speaking countries, and from the point of view of this theory this question could have no significance, since no electric fluid of any kind was assumed in the Faraday theory.

Since the discovery and isolation of the electric fluid by J. J. Thomson and his followers at the close of the 19th century, the question as to what part this fluid takes in the attraction or repulsion of electrified bodies has assumed its earlier importance, but the electrical theory of the present time is not concerned with the physical interpretation of phenomena, but only with the mathematical statement of their quantitative relations, and all qualitative relations are being ignored. The problem of the nature of electric attraction accordingly remains in the hopeless condition in which it was left by de la Rive.

THE MIOCENE SHORE-FISHES OF CALIFORNIA

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RECENT studies of the fossil fishes in the Miocene deposits about Los Angeles and at Lompoc in Southern California, have enabled us to distinguish about sixty-five species of bony fishes, besides a dozen or more species of sharks. Most of the latter are from the shales of Kern County, north of the Tahachapi range. With the exception of two extinct types (*Hemipristis* and the so-called *Wodnika*) the genera are all still represented on the coast. The present paper deals with true fishes only and these belonging to a period roughly estimated as two million years ago.

The study of these fishes of California shows certain facts very clearly.

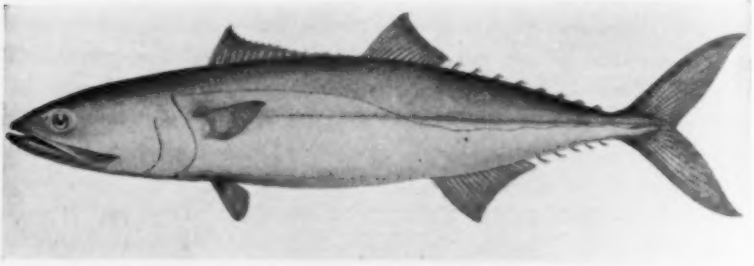
1. The present fauna of California is derived from it, with a certain admixture from the north and from Japan. In the Miocene fauna so far as known there are no types characteristic of Japan.

2. The Miocene fauna is a transitional one, having its roots in the Eocene or Cretaceous. But of neither of these periods have representatives been found in Pacific Coast deposits either in America or Asia.

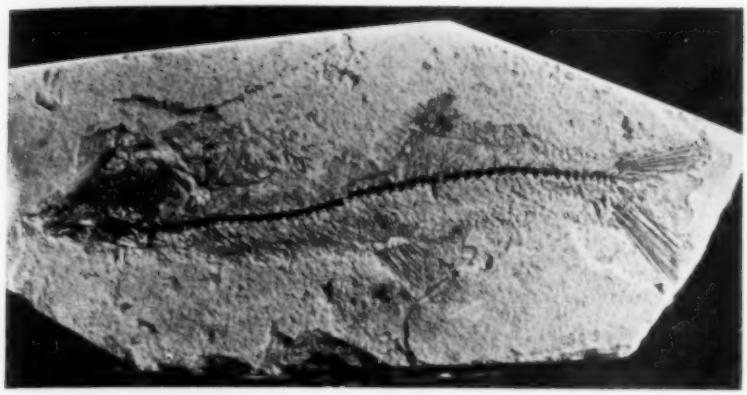
3. The Tertiary fauna of California is nearly all included in families still extant on the coast. All of the species are distinct from their living allies, and most of them must be placed in different genera.

4. The Miocene fauna is plainly ancestral to the present one.

5. The most striking difference which appears is that thus far we have found no trace among the fossils, of the *viviparous* surf-fish (*Embiotocidae*) which form so conspicuous a part in the existing fauna of



THYRSOCLES VELOX (JORDAN AND GILBERT) RESTORED



THYRSOCLES VELOX (JORDAN AND GILBERT) LOMPOC
A Mackerel, Allied to the Spanish Mackerel, Scomberomorus Maculatus (Mitchill).

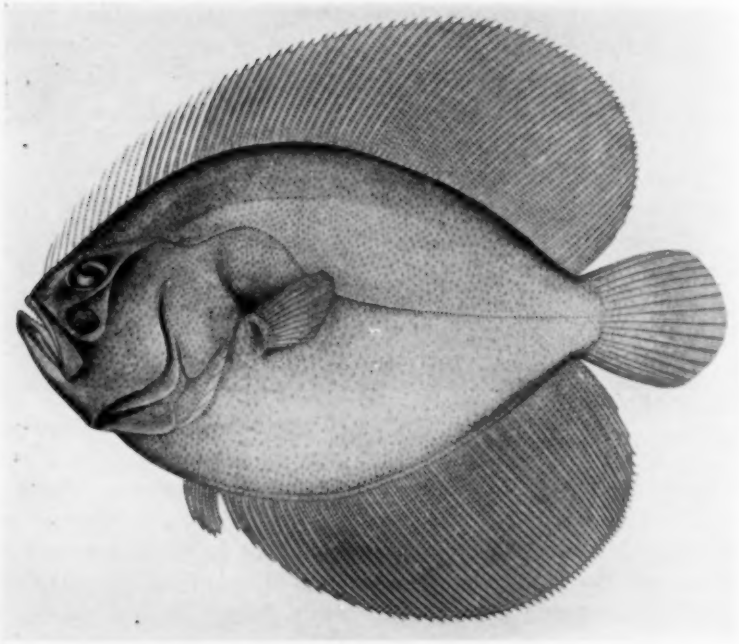
California, and which should abound in just the conditions in which fossils have been preserved. As two genera (*Ditrema Neoditrema*) of this family, representing different sections, are found in Japan, it is possible that the California surf-fishes are of Asiatic origin and have crossed to California in relatively recent times. Among the fossil fishes actually known we find none which suggests any affinity with Asiatic forms. Most of them are distinctly characteristic of California, a few only belonging to types now wanting in California but found in the Gulf of Mexico and in one or two cases in the Mediterranean.

Besides the surf fishes there are some other forms rare or missing which one might have expected to find. Gobies are very scarce although species are now abundant in all shallow waters along the coast. Sculpins (*Cottidae*) now extremely abundant along the coast are wanting. As the Okhotsk region is their center of distribution, they may be late comers in California. There are no sardines, anchovies, or true herring, the extremely numerous herring-like forms being all of extinct genera. We find no blennies, which is also an unexpected fact, as numerous species frequent just such small bays as then occurred in the Archipelago about Los Angeles. There are also no Labroid fishes, forms which now abound in the kelp banks outside the bays.

6. No species either distinctly tropical or distinctly subarctic appear among these Tertiary fishes. We must therefore conclude that the Miocene temperature differed little from that which obtains at present.

7. It is evident from the absence in the deposits containing fishes, of silt or other rain-washed material, that the climate was arid. In the Lompoc deposits of pure diatoms there is no sedimentary material whatever.

8. The localities in which fossil fishes have been found are of two categories:



ZORORHOMBUS VELIGER, JORDAN, (RESTORED)
A flounder allied to the European brill. Bothus rhombus, L.

(a) Shallow inlets within a group of small islands scattered about in the region now comprised in the counties of Los Angeles and Orange. The deposits in these little bays are mixed diatoms and fine clay, and the individuals are all either of species of small size or else the young of larger forms. In a few places individuals are found in clay or in fairly hard sandstone, more rarely in pure diatoms. It is a curious fact that the species found about Los Angeles are with the possible exception of two small fishes (*Lygisma, Quaesita*) all different from those taken in the diatom beds at Lompoc.

(b) The deposits of pure diatoms, unmixed with sand or clay, and rarely showing other organisms. Here are found multitudes of fishes, a few birds (petrels, gannets and wading birds) and an occasional porpoise. We found no crustaceans and no echinoderms. There are a few annelids, in one place a small clay bank burrowed full of holes by *Pholadided* or some similar mollusk, and in another place a single shell of some species of *Arca*. With the diatoms are occasional microscopic rhizopods and spicules of sponges.

The Lompoc deposit fills what was once a small narrow-mouthed or bottle-shaped inlet, on the north side of the Sierra Santa Ynez, the backbone of Santa Barbara County. Since these mountains rose from the sea, this little bay of Lompoc became filled with diatoms in in-

credible numbers to the depth of 1,400 feet. A little stream having eroded one side and large cuttings having been made for commercial purposes, we may now see a section of the whole mass from top to bottom. I have elsewhere[1] shown that a species of herring (*Xyne grex*) had at one time gathered in such numbers as to cover the whole floor of the bay to the exclusion of all other kinds of fish. This was at a level of 950 feet above the sandstone and shales on which the all diatom deposits rest. Among these millions on millions of herring young specimens are not found, all the individuals ranging from 6 inches to 8 inches in length, and not a foot in the whole four square miles so far as yet exposed has less than eight or ten of these fishes. In one single place all by themselves there is a deposit of young herring two or three inches long.

Dr. Edward C. Franklin figures on data which I have furnished that there must have been some 1,200 millions of these herring and that the number of diatoms in the whole bay might be represented by the unit 1 followed by at least 30 ciphers.

Among the herring we find no other kinds of fish whatever, and the question of what caused the sudden death of this vast multitude and the sudden burial in clouds of white diatoms constitutes a problem very difficult to solve. The only clews to the solution have been offered by Dr. Albert Mann, who suggests that the great crowding, whatever its cause, may have raised the temperature of the water, a matter to which

ZORORHOMBUS VELIGER, JORDAN, LOMPOC

1 "A Miocene Catastrophe" *Natural History*, American Museum, New York, xx, p. 18, 1920.

herring are peculiarly sensitive. The bulk of the other fishes found are predatory forms which have come to this bay in search of the herring. Two specimens of a large mackerel have herrings in their stomachs. These various forms I have described in two papers written in collaboration with Dr. Gilbert of Los Angeles. These are "Fossil fishes of Southern California" (David Starr Jordan and James Zaccheus Gilbert), Stanford University Publication, University series, 1919 (Sept. 6) and "Fossil fishes of diatom beds of Lompoc" (Jordan and Gilbert), l. c., 1920 (February).

No fossil fish is ever quite complete—one part or another is wanting. Ordinarily the head is the least satisfactory part. While the bones of the skeleton are picked clean by small organisms in the sea, the soft mass of the brain decays and in rotting it disintegrates the bones which lie around it. Although in most fishes the bones of the head are especially firm and hard, they are very seldom preserved in fossil forms and the student of bony fishes is obliged to give his attention to the skeleton and to the neural and haemal structures which spring from it. The position of the fins can be made out from these bones, but the rays are usually broken. Hence, however determined, there are always elements of doubt as to the accuracy and completeness of any restoration.

No traces of sharks are found in the diatom deposits although multitudes of sharks' teeth are found in the rocks which in other regions overlie the deposits of diatom. As each living diatom contains a minute droplet of oil, it is thought that the great oil deposits of Southern California may come from these masses of diatoms, and it is thus evident that the abundance of sharks' teeth may be an indication of oil. This is especially true in Kern County, where sharks' teeth exist in enormous abundance. It is possible that the oil escapes to the air in regions where, as in Lompoc, the diatom deposits are exposed; but where they are covered by later layers of sand and shale, the oil has been preserved to our own time.

A CALIFORNIA ELK DRIVE

By Dr. C. HART MERRIAM
WASHINGTON, D. C.

CALIFORNIA enjoys the distinction of having within its borders a number of animals and plants that do not inhabit other parts of the United States. Among these are several giants—the redwood of the coast and the bigtree or giant sequoia of the Sierra; the great California condor whose spread of wing equals if it does not exceed that of the condor of the Andes; and several species of grizzly bears culminating in the huge *Ursus magister* of the Cuyamaca and Santa Ana Mountains, now believed to be extinct.

Another interesting animal peculiar to the state, though by no means a giant among its kind, is the valley elk (*Cervus nannodes*), a species now confined to the south end of the San Joaquin plain but formerly abundant throughout the Great Interior Valley. Within the memory of men now living, large bands of these elk inhabited the tule marshes and sloughs of Tulare, Buena Vista, and Kern Lakes, and those bordering the San Joaquin and Sacramento Rivers, but a couple of decades ago the handful of survivors had drifted south to the southern border of the Tulare plain and had there made their last stand. The exact locality is the neighborhood of Buena Vista Lake, on what is known as Buttonwillow Ranch—one of the vast cattle ranches of the Miller and Lux Company.

Here they had a measure of protection but proved costly wards, making light of the high enclosing fences and playing havoc with the alfalfa and other crops. In the spring of 1904, Miller and Lux offered, through the Biological Survey of the Department of Agriculture, to present the herd to the Government. The offer was accepted, it being agreed that the ranch owners should corral the animals. But what to do with them was a serious question. However, a location was finally selected, on Middle Fork Kaweah River within the boundaries of the Sequoia National Park, where, through the courtesy of the Department of the Interior, I was permitted to establish and fence an elk park.

Miller and Lux had previously built a corral for shipping cattle; it was on the railroad 4 miles west of Buttonwillow at a place called Lokern. The plan was to drive the elk into this corral, which had been strengthened for the purpose and had been extended by the addition of long arms reaching far out on the plain.

The country is desert, comprising broad stretches of bare alkaline clayey and sandy soil, dotted at intevals with dull desert brush—a hot arid uninviting region, bounded on the south and west by the barren treeless foothills of the Templor and San Emidio Mountains—a region strikingly unlike that inhabited by the elk of the Rocky Mountains and Pacific Coast.

There were, we were told, three bands of elk: the main band numbering about 100; another of about 40; and an independent group of five very old bulls. The main herd, composed of cows, calves, two-year-olds, and a few adult bulls, had been for some time in the habit of feeding nightly in an alfalfa field a few miles southwest of Buttonwillow; the next largest band ranged a little farther west; while the small group of very old bulls could usually be found not far away.

The plan was to drive the main band from their nightly feeding ground to the corral, a distance of 6½ miles. The date had been set for November 12, 1904, and riders of neighboring ranches had been invited to take part. About 35—all expert vaqueros and cattle-ropers—had volunteered. Some went out the night before and camped along the route of the proposed drive, but the main body set out from Buttonwillow in the very early morning—long before daylight—in order to get behind the elk, between them and the foothills, while it was still dark.

The affair was in charge of the superintendent of the ranch, James Ogden, who went with the vaqueros to personally direct the drive.

THE LEADER OF THE HERD

They rode quietly to the far side of the alfalfa field in which the Elk were feeding and waited for them to come out. The place is where the level Joaquin plain ends, giving way to the barren foothills of the San Emidio and Templor ranges that stretch away to the south and west. The riders were expected to prevent the elk from entering the hills and to drive them slowly to the corral.

I did not take part in the drive, but accompanied by my then assistant E. W. Nelson (now chief of the Biological Survey), went direct to the corral and waited. We had arranged to photograph the incoming elk, and were also charged with the duty of keeping the onlookers from crowding forward and frightening the approaching animals. While waiting, we saw from time to time moving patches of dust; they appeared in various directions, all heading toward the corral, and were caused by persons from distant ranches riding in to witness the drive. Some came on horseback, some in buggies, some in heavy ranch wagons.

Suddenly, far away to the southeast, a very different cloud appeared; it was a broad low sheet of dust moving steadily westward, obviously coming nearer. Instantly all eyes were strained. One man climbed the water tank, from which point of vantage he called out that he could distinctly see elk in the front of the moving dust. Our spirits rose; all was excitement at the corral. Then the dust vanished—almost as suddenly as it had appeared—and we saw it no more.

In the course of an hour a rider arrived with the depressing news that the elk had broken for the hills and could not be turned; they had charged the line of oncoming vaqueros, had pushed on between the horsemen and escaped to the hills. A few had been pursued, roped, and 'hog-tied', and a horseman had been sent to the ranch for wagons to bring them in.

After a long wait the first wagon arrived, drawn by six horses. On its broad platform were three elk, flat on their sides, each with all four legs lashed together. There was an old bull with large antlers, battered and broken from much fighting, a two-year-old bull with long spike-horns, and a calf about two thirds grown. They had been injured in the beginning, in the roping and violent fighting before they were thrown and tied, and during subsequent struggles had beaten their heads against the hard floor boards of the dead-ax wagon. The calf was already dead; the others were nearly paralyzed from lying so long in one position in the hot sun.

The wagon was driven into the corral, where the two live elk were seized, carried, and dragged into one of the enclosures. Then the ropes binding their feet were loosed and the gates closed.

The animals had great difficulty in getting up and still more in

ARRIVING AT THE CORRAL, "HOG-TIED"

standing after they were up, and were some time in recovering the use of their legs.

Nevertheless, the old bull did things that amazed the onlookers. When roped he had fought so furiously that the skill and agility of the vaquero were taxed to the utmost to save himself and his horse from a bloody death. And when in the corral, no sooner were the ropes cut than the bull charged with such earnestness—in spite of the fact that he was unable to stand still on his feet—that the men were obliged to escape over the fence with the utmost promptness. He was 'game' from the start, and never for an instant relaxed his determination to fight every animate thing within reach. Discovering the spike-horn bull, whose fetters had been loosed simultaneously with his own, leaning against the corral fence near by, he instantly lowered his head and charged, driving his strongly curved brow-tines into the side of the younger animal, which soon began to bleed at the mouth and nose, and later died. The old bull, although for some time unable to walk, or even to stand erect without leaning against the corral, was nevertheless able to make sudden rushes at those who were bold enough to enter the enclosure or to sit on the nearby fence. To prevent further harm he was again roped and stretched, and his horns were sawed off close to his head. This was intended to break his spirit and render him easy to manage, but as subsequent events proved, it had no such effect.

Shortly after noon the second wagon was seen approaching. It had been obliged to travel a long distance over the dry hills to pick up the widely scattered elk, of which it brought five—an old cow, a two-year-

SAWING OFF HIS HORNS IN THE CORRAL

old bull, a cow calf, and two bull calves. Three of these were already dead, only the cow and one of the bull calves reaching the corral alive. This made 8 elk at the corral, 4 alive and 4 dead.[1] Of the 4 living, it will be remembered that one—the spike-horn buck—had already received a mortal wound. The cow, calf, and wounded spike-horn were moved from the corral compartments to the middle passage and thence through the narrow chute into a cattle car, which had been brought for the purpose. This was accomplished without serious difficulty. But with the old bull the case was very different. He stubbornly refused to be either led or driven, and in spite of his hornless condition and the weakness of his legs, no one could be found who was willing to enter his compartment to argue with him at close quarters. His aggressive attitude continued and his face wore an expression of defiant rage. When any one approached, he dilated his nostrils, gritted his teeth, and uttered a low expiratory snort—the only noise he ever made.

Volunteers were called for, but no one responded. A hundred men, including the best riders and boldest vaqueros of the Joaquin, were gathered at the fence, but no one pressed forward to try his mettle with the hornless bull. Then Ogden, the superintendent, turning to his head vaquero, Billy Woodruff, asked if he was afraid to go in and get that elk out. Woodruff replied that if he could ride his horse in he would

[1] The skins and skulls of the elk that died during the drive were preserved and sent to the Biological Survey and are now in the U. S. National Museum. They proved to be a new species, which because of its relatively small size I named *Cervus nannodes*.—Proc. Biological Soc. Washington, Vol. 18, pp. 24-25, Feb. 2, 1905.

do it, whereupon he swung himself into the saddle and rode through the gate.

The scene that followed is not likely to be forgotten by any who witnessed it. Woodruff's horse was a magnificent animal—nearly black, large, broad-chested, powerful—experienced and daring in everything relating to the roping and handling of cattle. From first to last he and his rider moved as if impelled by a single purpose. There seemed to be no attempt to guide on the part of the man, and no attempt at independent action on the part of the horse—they were one, not two. The instant the horse entered the enclosure it was evident to everyone that he not only understood his master, but also that he thoroughly understood the business he was there for. He, as well as the onlookers, knew that he was there to get that elk out of the corral. But no sooner had he entered the gate than the bull, who by this time had regained the use of his legs, met him with a fierce charge, striking him full in the breast with the butts of his sawed-off horns. The horse received the shock without a tremor and took in the situation at a glance. As the elk backed for a second charge the horse sprang forward and crowded him back to prevent him from getting leeway for another rush. By force of greater weight the horse pressed his adversary to the fence and tried to push him out through the corral gate. But the elk stubbornly refused to go, and in spite of inferior size punished the horse so severely that it is a marvel he didn't break and run. The elk was an experienced, aggressive, and expert fighter; his strength, activity and quickness were amazing, and the way he rained fearful blows on that horse was painful to behold. By turning and slipping a little to one side he managed repeatedly to swing his head so as to strike the horse in the ribs and with the stubs of his horns to tear and fray the fenders and sweat leathers of the saddle. Once he hit the rider a glancing blow on the leg which nearly broke it. The horse tried hard to receive the attacks on his breast, and did so whenever possible, never for an instant relaxing his efforts to crowd the animal out of the corral; but the elk, taking advantage of the corners, could not be forced out.

Finally, realizing the hopelessness of further attempts at crowding, Woodruff and the horse tried a new dodge. They backed slowly out to and through the open gate. This gave the elk the opportunity he had all along sought of getting a running start for his blows, with nothing to intercept or lessen their force, and he availed himself of it to the utmost. For a distance of thirty or forty feet the brave horse backed slowly to the gate, receiving terrible punishment from the sledge-hammer-like blows, which he received full on the breast. In this way the old bull was slowly enticed to the open gateway, where, as if realizing the trick, he suddenly stopped. But it was too late. The gate

opened in, and at this moment several men who had been watching from the top of the fence, dropped down quickly behind the gate and by a united effort pushed it shut, thus crowding the elk out into the narrow middle passage, where the battle was immediately resumed. Here the absence of corners and angles in which the elk could gain a purchase soon told in favor of the horse, who, straining every muscle, forced his adversary into the narrowing chute that led to the car. But even now the elk had no thought of giving in. Once, by a tremendous effort, he rose up under the horse's breast and actually lifted the heavy animal off his fore feet. Then the horse, recovering, lowered his broad breast against the elk and by a swift and powerful rush pushed him backward through the narrow chute to the open door of the car. Here the elk, finding himself unable to stand against the force that was driving him backward, and unable to see where he was being carried, whirled and sprang into the car. The shout that burst from the throats of the onlookers was in appreciation of the achievement of Woodruff and his splendid mount; while a second shout voiced admiration for the undaunted valor of the poor old bull who, against such tremendous odds, had fought to the very last.

After all the elk had been brought in, the vaqueros and spectators, about a hundred in all, were treated by Ogden to a barbecue lunch. Half a beef and some elk meat had been roasted over coals in a long trench, a huge pot of coffee was boiled, and there was bread enough for all.

The vaqueros had many tales to tell of the events of the chase, the main facts of which appear to be: At early daybreak a small bunch of bull elk with antlers came out of the alfalfa field, ran off to the westward and were not again seen. A little later the main band appeared. Their numbers were variously estimated at from 85 to 105. They consisted mainly of cows, calves, and two-year-old males with spike-horns. There were only two, or at most three, adult males with branching antlers. The herd set out in a northwesterly direction along an old channel of Kern River, going toward the corral. The riders were behind, between them and the Templor foothills. The elk moved off on an easy trot—a pace that made it necessary for the horses to strike a lively gait to keep up. For two or three miles the elk held their course toward the corral and the riders began to think it would be an easy matter to drive them in. Then suddenly, and without apparent cause, the band turned abruptly to the left and made for the hills. This brought them face to face with the riders, who had kept a parallel course. The men shouted, threw up their arms, and bore down upon the rapidly approaching elk, but the elk paid absolutely no attention to them and continued their course to the hills. When the two forces met, the elk passed between the horses, some so close that the horsemen

TAKING ELK TO THE PARK, NOVEMBER, 1914

were obliged to get out of the way to escape injury—for the bulls with horns were exceedingly dangerous and could not be closely approached without risking the lives of the horses. But most of the animals were females and young.

Finding it impossible to drive the elk, several of the vaqueros yielded to temptation, gave chase to an individual animal, overtook it, kept it alongside for some distance, crowding it with the horse, hitting it repeatedly with the riata, or even in some cases kicking it, in a futile effort to turn it back, and finally, in sheer desperation, roping it. The two adult bulls with branching antlers, two spike bucks, a cow and several calves were lassooed, thrown, "hog-tied"—the front and hind legs lashed firmly together—and left on the ground to be picked up later by the wagons. One of the old bulls was so far away that the wagons did not reach him at all, and later a horseman was sent to liberate him. The other—the first one roped—was the terrible fighter already mentioned at the corral. He was believed to be the leader of the band and obviously had earned the distinction. From first to last he had shown no fear and had fought every living thing within reach.

The car containing the four elk was taken to Exeter, whence the animals had to be hauled by wagon 35 miles to the park. The wounded spike-horn and the old cow had died, leaving only the old bull and the calf.

In anticipation of the moving, three huge and very strong wagon-crates had been built, each to be hauled by a six mule team. Each crate was divided into six compartments, separated by gates that could be lifted up between solid uprights; and the rear end also had been made a sliding gate.

When the car containing the elk arrived at Exeter, one of the wagons was backed up against it and so placed that the elk could step directly from the car into the cage. The calf did this promptly, but the old bull declined to enter. While in transit he had fought and butted and kicked until he had splintered several of the side boards of the car. A half barrel of water that had been put into the car stood in the doorway. By means of a pole it was upset and pushed to one side. No sooner had this been done than the elk, seeing it in a new position, charged and dealt it a resounding blow that sent it rolling over the floor. This evidently pleased him, for arching his back and leaping forward he struck it again and again, making a great noise, and followed it around the car, butting it furiously as if it were the cause of all his trouble.

Finally, after repeated efforts to drive him out had failed, a rope operated by long poles was slipped over his neck, he was dragged through the open door into the crate and the two rear gates were closed behind him. This enraged him still more and he attacked the crate with vigor, butting furiously in one spot until the boards began to give way. Meanwhile the men on top of the crate suceeded in forcing down the gates immediately in front and behind him, so that he was confined in a narrow cell only two feet in width. Finding that he could no longer butt, having no room to swing his head, he at once began to kick and kept on kicking, dealing the boards behind him a series of rapid sledge-hammer blows until it was evident that they would soon be reduced

CALF ELK AFTER ARRIVING AT THE ELK PARK

to splinters. When he had kicked as long as he could with one foot, he would change and kick with the other. The force and rapidity of the blows were astonishing; it seemed incredible that his strength could hold out so long.

When the wagon reached Lemon Cove (a distance of 12 miles) the constant kicking had so demoralized the crate that it had to be taken to a blacksmith shop for repairs. An old ranch gate was secured and roped on the outside, and the crate was further strengthened by additional iron bolts. When Three Rivers was reached at 9 in the evening, still other repairs were necessary, and a halt was made for the night. In the morning the driver, who had laid his bed close to the wagon, announced that the elk had kicked all night, never resting more than five minutes at a time.

After again repairing the crate we set out for the park, still 12 miles distant. Arriving at the enclosure, the wagon was driven through the gate and turned around, facing the entrance; the horses were taken out, and holes were dug for the hind wheels in order to let the wagon bed down to the level of the ground. Then the rear gates were lifted, giving the calf his liberty. He was not at all afraid and at once ate grass from my hand. But he did not like the looks of the bull and soon climbed a nearby hill. Then the other gates were raised, giving the bull an opportunity to step out. For the first time since his capture he did what was wanted; he voluntarily crept to the rear of the wagon and hobbled out on the ground. Looking around for an enemy to attack and not seeing any—some of the men having stationed themselves outside the park fence, the others on top of the crate—he set out for the river, only a few rods away. His courage had not forsaken him, but his strength had; he was no longer the proud aggressive wild beast he had been. He had reached his limit. The terrible ordeal he had been through: the struggle incident to his capture; the rough hot ride to the corral, hog-tied, on the hard floor of the dead-ax wagon; the outbursts of passion in the corral; the fighting and second roping in connection with the sawing off of his horns; the battle with the big horse; the ceaseless violence of his destructive assaults first in the car, then in the crate, continued for three days and nights, had finally undermined even his iron frame, so when at last he found himself free on the ground he presented a truly pitiful picture. With his head bent to one side and back curved, with one ear up and the other down, and with a dejected helpless expression on his face, he hobbled wearily away, barely able to step without falling. Slowly he made his way to the river, waded in, drank, crossed to the far side, staggered laboriously up the low bank, and lay down. The next day he was found in the same spot—dead.

Profiting by the failure to drive the elk into the corral in 1904, Mr.

Ogden in the following year adopted a wholly different plan, which proved far more successful. Instead of attempting to *drive* the animals he organized *a chase* by experienced vaqueros, the object being to rope the individual elk. The chase took place a few miles from Buttonwillow on October 15, 1905. Nearly 30 were roped. Of these, 3 died before shipment; 25 were shipped, and 20 reached the park alive, forming a splendid nucleus for a growing herd.

The wild elk remaining on the Buttonwillow ranch multiplied steadily, and their depredations on alfalfa and Egyptian corn were correspondingly severe. In 1914 the Miller & Lux Company decided to attempt the capture of a very large number and invited the California Academy of Sciences to take charge of their distribution. The offer was accepted, and Dr. B. W. Evermann, director of the Academy's activities, arranged for the shipment of the elk to municipal parks and other available tracts in different parts of California.

A new method was inaugurated by the superintendent, Mr. Ogden. A huge corral a quarter of a mile long was built in an alfalfa field to which the elk came every night to feed. Here on the night of October 11, 1914, 150 came into the corral and were enclosed, but the next day 90 escaped. Three days later about 25 more were captured. During the latter part of the month 54 were distributed to different localities in the state.

Again, in 1915, the same corral was used in the same way, resulting in the capture of more than 100 elk, of which 92 were distributed. At that time it was estimated by Dr. Evermann that the number still remaining in Kern County was between 350 and 400.

THE PROGRESS OF SCIENCE

THE SECOND INTERNATIONAL CONGRESS OF EUGENICS

In this journal special attention has always been given to problems of evolution, heredity and eugenics. As older readers of the THE POPULAR SCIENCE MONTHLY will remember, it gave the first American publication to the work of Spencer, and, to a certain extent of Darwin, Huxley and the other leaders in the development of the doctrine of evolution. It was indeed under the elder Youmans a journal primarily devoted to the cause of evolution at a time when the word stood for heresy not only with the general public, but also among most men of science.

During the past twenty years under its present editorial control, THE SCIENTIFIC MONTHLY has continued to devote a considerable part of its space to work bearing on heredity and eugenics. Francis Galton printed here articles laying the foundation of eugenics, and the leading American students of genetics—Brooks, Wilson, Morgan, Conklin, Davenport, Jennings, Pearl and many others have communicated the results of their work to the wider scientific and educated public through this journal. In like manner, many articles by leaders in the subject have been printed on human heredity in so far as it is open to experimental or statistical study, and in other subjects on which a science of eugenics must rest—population, birth and death rates, immigration, racial differences, human behavior, etc.

We are consequently pleased to be able to record the holding in New York City of the second International Congress of Eugenics and to print in the present issue of the MONTHLY several of the more important addresses by foreign representatives. Shakespeare left no descendants, and Ben Jonson remarked that nature, having made her masterpiece, broke the mold. The four sons of Charles Darwin have followed scientific careers, a fine example of family heredity and tradition. It is a special privilege to welcome to the United States and to print the address in advocacy of eugenics of Major Leonard Darwin, based so largely on the works of his father, Charles Darwin, and of his cousin, Francis Galton. We hope to be able to publish in subsequent issues a general account of the congress by Dr. C. C. Little, the secretary, and several of the papers containing the results of more special scientific research. The program was strong in genetics, in which America now probably is leading. But all the divisions maintained good standards, the more doubtful theories and premature applications of ignorance, to which newer sciences such as eugenics and psychology are subject, having been in general avoided.

THE MEETING OF CHEMISTS IN NEW YORK CITY

The sixty-second meeting of the American Chemical Society, held like the Congress of Eugenics in New York during September, may lead to the hope that the city will give as much concern to becoming the center of the scientific as of the financial world. It was partly an Anglo-American meeting, for the Society of Chemical Industry having met in Canada, a number of the English and Canadian members took part in the New York meeting.

When the visiting guests crossed the border into the United States at Niagara Falls, President Harding welcomed them with the following telegram:

It is a pleasure to extend greetings

to the gathering of American, Canadian and British Societies representing the chemical sciences and industries meeting on American soil. Probably none of the materialistic sciences holds promise of so great contributions to human welfare in the coming generations as that which your organization represents. The developments of applied chemistry involve both a possibility of vastly increased horrors in human conflict and alternately inestimable benefits to a peaceful civilization. Let us hope that a science so fraught with either good or vicious possibilities may be turned, through the wisdom of the nations, to the benefit and advancement of mankind.

The meeting in New York was appropriately presided over by Dr. Edgar F. Smith, lately provost of the University of Pennsylvania and twenty-five years before president of the society. At the opening meeting at Columbia University, addresses were made by Francis P. Garvan on "Chemistry and the State," by Sir William Pope on "Chemical Warfare" and Professor R. F. Ruttan on "Organization of Industrial Research in Canada." At the closing general meeting Dr. Smith gave the presidential address on "Progress in Chemistry." This address was preceded by the unveiling of the Priestley portrait which is to be placed in the National Museum, the unveiling being accompanied by a description of the life and work of Priestley, by Dr. C. A. Browne.

An international meeting was held in the grand hall of the College of the City of New York after an organ recital by Professor Samuel A. Baldwin.

Chemistry and Civilization: Dr. Edgar F. Smith, provost emeritus, University of Pennsylvania, in the chair.

Science and Civilization; The Rôle of Chemistry: Dr. Chas. Baskerville, director of the laboratories, College of the City of New York; chairman, International Committee.

Energy; Its Sources and Future Possibilities: Dr. Arthur D. Little, chemical engineer and technologist, Boston.

The Engineer; Human and Superior Direction of Power: Dr. Leo H. Baekeland, honorary professor of chemical engineering, Columbia University.

Chemistry and Life: Sir William J. Pope, professor of chemistry, Cambridge University.

Theories: Dr. Willis R. Whitney, head of research department, General Electric Company.

Research Applied to the World's Work: Dr. C. E. K. Mees, head of research department, Eastman Kodak Company.

Problem of Diffusion and Its Bearing on Civilization: Professor Ernst Cohen, professor of chemistry, University of Utrecht.

Catalysis; The New Economic Factor: Professor Wilder D. Bancroft, professor of physical chemistry, Cornell University.

THE AMERICAN PUBLIC HEALTH ASSOCIATION

A third scientific meeting, like the Congress of Eugenics and the Chemical meeting concerned largely with the public welfare, will be held in New York City during the autumn. The fiftieth annual meeting of the American Public Health Association will be the occasion of a health fort night from November 8-19. It is hoped that its slogan, "Health First," will stimulate interest throughout the country. Health fortnight will include three major divisions—a Health Institute from November 8-11; a Health Exposition, November 14-19; the Fiftieth Annual Meeting of the American Public Health Association, November 14-19.

The Public Health Exposition will be conducted under the joint auspices of the Department of Health of the City of New York and the American Public Health Association. Already allotments of space indicate that at least two entire floors of the Grand Central Palace will be occupied by the exhibitors. The exhibits will include those of educational and philanthropic organizations and those of commercial houses producing approved articles of health value. The

MAJOR DARWIN PROFESSOR OSBORN MRS. OSBORN
MEMBERS OF THE INTERNATIONAL CONGRESS OF EUGENICS

PROFESSOR MOERNS PROFESSOR SHULL DR. DAVENPORT
AT THE AMERICAN MUSEUM OF NATURAL HISTORY

profits from the sale of tickets, after the cost of the exposition and the convention are defrayed, will be devoted to establishing nutritional clinics for the benefit of undernourished children.

The Health Institute from November 8-11 will present to visitors an opportunity to see the operations of established methods applied to various phases of public health work. About forty demo strations have been planned.

Following the week of the institute and the observance of Health Sunday, will come the opening of the scientific sessions, the meetings of the American Public Health Association in celebration of its semi-centennal. The sessions will begin on November 14 and the headquarters will be at the Hotel Astor. The scope of the meet ings is indicated by their division into the following: General Sessions, Public Health Administration, Child Hygiene, Public Health Publicity and Education, Laboratory Section, Vital Statistics Section, Industrial Hygiene Section, and Food and Drug Section.

SCIENTIFIC ITEMS

WE record with regret the death of J. W. Richards, professor of metallurgy at Lehigh University; and of Dr. Arno Behr, the American industrial chemist; of G. W. Walker, the English seismologist; and of Henry Beaunis, known for his work on physiological psychology and hypnotism at Nancy and later at Paris.

DR. C. S. SHERRINGTON, professo of physiology at Oxford University and president of the Royal Society, has been elected president of the British Association for the meeting to be held at Hull in 1922. It is expected that the meeting of 1923 will be at Liverpool and the meeting of 1924 at Toronto.

THE University of Edinburgh has conferred the degree of doctor of laws on Dr. Irving Langmuir, of the research laboratory of the General Electric Company, Schenectady, who at the meeting of the British Association in that city opened the discussion on "The Structure of Molecules."

DR. ALEXIS CARREL, of the Rockefeller Institute for Medical Research has been elected a national associate of the French Academy of Medicine, of whom there are only twenty.

THE 1921 volume of the Summarized Proceedings of the American Association for the Advancement of Science, the publication of which has been delayed owing to the printers' strike, will soon be issued from the office of the permanent secretary of the association. The volume contains the old and the new constitution, the lists of officers, and references to *Science* for the reports of the Pacific Coast meeting (summer of 1915), the Columbus meeting (1916), the New York meeting (1917), the Pittsburgh meeting (1918), the Baltimore meeting (1919), the St. Louis meeting (1920), and the Chicago meeting (1921). It also contains the complete list of members of the association, corrected to June 15, 1921. Members who have already ordered the volume will be sent copies as soon as the book is published; those who have not ordered it may still do so, the price being two dollars, payable when the order is placed. The price to others is two dollars and fifty cents. The new list constitutes a directory containing the names, degrees, positions, addresses, etc., of about 12,000 scientific workers and others interested in scientific progress. It has been prepared from data obtained through special information blanks sent to all members.